Canada. Commission on the Feasibility of Refining Copper and Producing Metallic Zinc Commercially.
A record of the Investigation.
[Commmissions and Committees of Inquiry]

Imperial Munitions Board, Ottawa

A RECORD

OF THE

Investigation, Report and Subsequent Action of the Commission

Appointed by Major-General the Honourable Sir Sam Hughes, K.C.B., etc., Minister of Militia and Defence.

To investigate the feasibility of Refining Copper and Producing Metallic Zinc on a Commercial Scale in the Dominion of Canada.

From March to August, 1915.

Ottawa:
Dominion Printing and Loose Leaf Company, Limited
1916

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PREFACE.

This report is the outcome of an emergency situation. It sets forth the origin and object of the investigation as well as the result. It gives facts and opinions from men specially qualified to deal with the subject. The information given regarding the sources of supply of zinc and copper in the Dominion of Canada, together with facts relating to methods of manufacture, cost of production, and markets for products, should be of service to all concerned in the development of the zinc and copper industries in Canada.

The more important documents are printed *in extenso*, while in other cases a digest of the information is alone presented.

Practically pure metallic zinc is now being produced for the first time in Canada, as the result of these investigations.

The quality of the product is not only suitable for munitions of war, but also for domestic and export commercial requirements.

By September, 1916, the plant for the refining of copper, at present in course of construction, will be in operation and will add another important industry to Canada.

I am indebted to Mr. James J. Warren, Managing Director of the Consolidated Mining and Smelting Company for the photographs showing the buildings for the production of metallic zinc and the refining of copper, in course of construction.

DAVID CARNEGIE.

Ottawa, Ont., Aug., 1916.

July 10th, 1916.

Major-General the Hon. Sir Sam Hughes, K.C.B.,
Minister of Militia and Defence,
Ottawa.

Sir:—

Through the very kind and diligent efforts of Dr. Stansfield the belated record of the investigation appointed by yourself to consider the feasibility of refining copper and producing metallic zinc on a commercial scale in the Dominion of Canada is now completed. In my opinion the information contained therein will be of value to many in the Dominion, as it contains the mature opinions of the most expert men in Canada on the subjects dealt with.

I am proposing to the Imperial Munitions Board that the report be published. Before recommending this course, however, I should be glad to have your permission for its publication, particularly Section 13 which deals with the correspondence relating to the final action of the Canadian Government in the matter.

The real work of the Commission has fallen principally upon Dr. Stansfield and Dr. Wilson, and it is gratifying to know that as the outcome of the work inaugurated by yourself, zinc to-day is being refined in Canada. Already 210 tons have been supplied.

The plant also for the refining of copper is nearly completed and very soon refined copper will be made for the first time in Canada.

In addition to these new industries the Dominion Copper Products Company of Montreal has been established to manufacture copper bands for munitions and other copper products and will use part of the refined copper made in Canada.

I am, Sir,

Your obedient servant,

DAVID CARNEGIE.

Minister's Office,
Ottawa, July 14th, 1916.

Dear Colonel Carnegie:—

Permit me to thank you very sincerely for your kind letter of the 10th instant, regarding the publication of your report upon your work and the development of the zinc and copper industry in the Dominion of Canada.

I have great pleasure in endorsing your proposition to this end in the hope that it may inspire the people of Canada to have faith in their own country and in its resources; to instill into them that confidence necessary to the development of such and to encourage them in developing the industries incident to the zinc, copper and kindred products.

I join you in the hope that these industries, developed for the war, may be pursued in time of peace for the great commercial trade of the Empire.

Faithfully,
(Sgd.) SAM. HUGHES.

Colonel D. Carnegie,
Imperial Munitions Board.
Ottawa, Ont.

Commission appointed by the Minister of Militia and Defence to investigate the feasibility of Refining Copper and Producing Metallic Zinc on a Commercial Scale in the Dominion of Canada

SECTION 1. INTRODUCTORY.

1. MEMBERS OF THE COMMISSION.

HON. LT.-COL. DAVID CARNEGIE, M-Inst. C.E., Chairman
Ordnance Advisor to Shell Committee.

DR. A. W. G. WILSON,
Chief of Metal Division, Mines Branch, Ottawa.

DR. A. STANSFIELD,
Professor of Metallurgy, McGill University.

INTRODUCTION.

The following report is the outcome of investigations instigated by the Honourable the Minister of Militia and Defence, General Hughes, with the support of Sir Robert Borden, G.C.M.G., Prime Minister of the Dominion of Canada.

FORMATION OF THE COMMISSION.

The Commission was formed after several conferences concerning the supply of copper and zinc for the British War Office contracts, with the Minister of Militia and Defence, the Chairman of the Shell Committee, Brig-General Bertram; David Carnegie, Ordnance Advisor, and finally with Sir Robert Borden, the Prime Minister.

The uncertainty which existed in February, 1915, as to what action might be taken by the United States regarding the export of zinc and copper from that country to Canada and the necessity for taking no risks in the matter, led to the conclusion that it was desirable to investigate the feasibility of refining copper and producing metallic zinc in Canada.

On the recommendation of Mr. Carnegie, Dr. A. W. G. Wilson, Chief Engineer of the Metal Division, Mines Branch, Ottawa, and Dr. A Stansfield, Professor of Metallurgy, McGill University, were appointed by the Minister of Militia and Defence, members of the Commission.

2. *THE SCOPE OF THE INVESTIGATION.*

The scope of the investigation might be briefly summarized as follows:—

(1) To ascertain if the copper ore deposits of the Dominion and particularly those of British Columbia, would produce sufficient blister copper annually and for a sufficient period, to warrant the establishment and maintenance of a plant to refine copper on a commercial basis.

(2) To determine the best location for such a plant, having in view the cost of: site, plant, ores, matte and blister copper, labour, fuel, power and distribution of products, also the comparative cost of refining copper in Canada and in the United States.

(3) To ascertain what would be the attitude of American refiners of copper to the establishment of a copper refining plant in Canada, having regard to the American copper mining and smelting interests in the Dominion. Also to consider what action might be taken by the American refiners to prevent the marketing of Canadian copper.

(4) To consider the value of the by-products obtained by refining copper and the markets for such by-products. Further to ascertain what industries in Canada would be benefitted by refining copper in Canada, and what new industries might be established.

(5) To consider the best form of assistance which might be given to develop such a project.

(6) To make a similar investigation with respect to the metal zinc.

3. *METHOD OF INVESTIGATION.*

In order to confine the enquiry to the subjects under investigation, the Members of the Commission prepared a list of questions upon which full discussion and careful consideration were invited.

The Commission informed those to whom the questions were given, that they did not consider them exhaustive, but merely as an indication of the nature of the enquiry and as a guide to discussion.

THE FOLLOWING IS A LIST OF THE QUESTIONS SUBMITTED:

GENERAL.

1. What in your opinion are the prospects for the establishment in British Columbia, of a copper refinery that could be a commercial success?
2. What location or locations would, in your opinion, be the most advantageous, and why?
3. What are the comparative costs in Canada and the United States for:
   A. Labour,
   B. Power,
   C. Fuel,
   D. Cost of living.
4. What production of blister copper per annum would be needed to support a copper refinery on a commercial basis?
5. What quantity of zinc ore is necessary to insure the successful operation of a zinc smelter?
6. What by-products would be available and what disposition could be made of them?

MINING.

A. Copper Mining.

1. What prospect is there of the copper production on the coast of British Columbia being increased?
2. What properties now undergoing development give promise of adding to the coast production, apart from increases which may be expected from the mines now being operated?

B. Zinc Mining.

3. What zinc prospects are known on the coast?
4. Have they ever produced ore and how much?
5. Have you accurate information as to the tonnage available?

FUEL.

A. Coal.

1. What is the cost of coal at the pit mouth?
2. Have you any data on the actual cost of production?
3. What does coal cost at Ladysmith?
4. Are the Vancouver Island coals good coking coals?

B. Oil Fuel.

1. What does crude oil and what does fuel oil cost on the Pacific Coast?
2. What are the sources of supply?
3. What is the equivalent quantity of each, crude oil and fuel oil, in comparison with one ton of coal from Nanaimo or Wellington collieries?

LABOUR.

1. What are existing labour conditions on the coast? Union? Open shop? In what trades?
2. What is the prevailing scale of wages for skilled and unskilled labour in the various trades?

POWER.

1. At what points on the coast is electric power now available?
2. Is it being utilized at all?
3. What capacity is lying idle?
4. Where could the cheapest electric power be obtained?
5. What would be the lowest cost per horse power year, or per killowatt hour?
6. How much would be available?

MARKETS AND MARKETING.

1. Where would refined copper from British Columbia be marketed?
2. Where would refined zinc from British Columbia be marketed?
3. What would be the influence on other Canadian industries if a copper or a zinc refinery were established on the coast?

4. How will the United States copper refining companies view the establishment of a refinery in Canada?

FREIGHT.

1. What are the existing rates on copper and zinc ores, and on blister copper from:—
   (*a*) East Kootenay to Vancouver?
   (*b*) Boundary to Vancouver?
   (*c*) Boundary to New Jersey or Montreal?
   (*d*) Coast to Coast (by rail)?
   (*e*) Coast to Coast (by Panama)?
   (*f*) West Coast to European markets?

The foregoing questions were submitted to men interested in mining and metallurgy, experts who met the Commission at the meetings convened by the Mining Committees of the Board of Trade in the cities of Victoria and Vancouver, B.C. Minutes of the proceedings of all meetings were recorded.

Similar questions were also submitted to the mining and smelting companies visited by the Commission and to individual experts, who kindly consented to give their opinions.

The opinions expressed and the conclusions arrived at by the various experts are embodied in the report.

At the conferences, Dr. A. W. G. Wilson directed his attention principally to the copper situation and Dr. A. Stansfield confined himself especially to the consideration of zinc production.

Colonel Carnegie's secretary, Mr. T. W. O'Neill, acted as secretary to the Commission.

We wish to record our thanks to all who have given assistance during the investigation. We desire to name in particular the following:—

The Honourable J. W. Bowser, Attorney General, B.C. Acting Premier during our visit.

R. E. Gosnell, Esq., Victoria, B.C., Private Secretary to Sir Richard McBride.

W. Fleet Robertson, Esq., Victoria, B.C., Provincial Mineralogist.

Col. E. G. Prior, Victoria, B.C., President Board of Trade.

A. C. Flummerfelt, Esq., B.C.,

Chairman and Members Mining Committees, Victoria and Vancouver, B.C.

Chairman and Members Boards of Trade, Victoria and Vancouver, B.C.,

and all others who have supplied any information on the subject in question.

(Signed) DAVID CARNEGIE,
Chairman of Commission.

4. *VISIT TO BRITISH COLUMBIA.*

The members of the Commission left Montreal and Ottawa about the 30th of March, 1915, and proceeded to Trail, B.C.; spending a few hours on the way at Medicine Hat. The Commission had interviews with officers of the Consolidated Mining and Smelting Company at their smelter at Trail on the 5th and 6th of April. A short time was spent in Nelson on the 7th April, from which point the Commission travelled to Victoria. A meeting was held with the Victoria Board of Trade on the 12th April, and with the Vancouver Board of Trade on the 13th April. The Commission visited the concentrating plant at Britannia Beach on the 14th April and then returned to the East.

5. *PRELIMINARY CONCLUSIONS REGARDING THE REFINING OF COPPER IN CANADA.*

(1) We are of the opinion that the time is opportune to commence refining copper in Canada.

(2) The best location where to begin refining copper is, in our opinion, at the works of the Consolidated Mining and Smelting Company, Trail, B.C., because:—

- (*a*) The works are owned and operated by Canadian capital.
- (*b*) The Company is free to commence refining copper immediately, as it has no binding contracts with companies in the United States, such as exist for at least two years between the copper producers at the coast and the refineries in the United States.
- (*c*) The Companies at the coast are all controlled by firms in the United States.

(*d*) The Consolidated Mining and Smelting Company of Canada now possesses an efficient staff capable of managing a copper refinery.

(*e*) As the electrolytic refining of lead has been carried on successfully at Trail for some years past the Company is in a more favourable position to produce electrolytic copper more economically and at less initial cost of plant than any of the other companies on the coast.

(*f*) The establishment of a refinery at Trail would in no way interfere with the subsequent establishment of a refinery at the coast, should this be found advisable.

THE ADVANTAGES OF REFINING COPPER IN CANADA.

(1) The establishment of a copper refinery in Canada means the beginning of a new industry, which will lead to the manufacture of copper products now imported from the United States and elsewhere, such as wire, bars, sheets, tubes, etc.

(2) It means that the money value of the labour now enjoyed by the United States, in manufacturing the imported products, would be kept within the Dominion. The value of the imported copper products is upwards of $5,000,000 annually. This amount does not include the value of brass imported.

(3) It means that as approximately one-third of the value of the copper produced in the Dominion now goes to the United States to pay the cost of refining, freight and marketing, that amount would be saved to the Dominion.

[Note 1—It costs from 8c to 11c per lb. to produce the finished product (ingot copper ready for the manufacturers) from copper ore in the mine. The market price of copper usually varies from 12c per lb. upwards. At present it is about 20c per lb.

COPPER AVAILABLE

Dr. Wilson estimates that there are over one thousand million pounds of copper available in the known ore deposits of British Columbia, most of which will be mined in all probability during the next fifteen years.

The undeveloped resources cannot be estimated.

TOTAL COPPER MINED ANNUALLY.

The total copper mined and partially manufactured in Canada is about 75,000,000 lbs. annually. This will be increased probably to 100,000,000 lbs. within two years.

The total copper mined and partially manufactured in British Columbia, is about 45,000,000 lbs. annually. This, too, will be increased within the next two years.

(Signed) DAVID CARNEGIE.

6. *PRELIMINARY CONCLUSION REGARDING THE SMELTING OF ZINC ORES IN CANADA*

The following are the conclusions that have been reached as the result of these investigations, together with an indication of the reasons leading up to them. Further particulars will be found in the report.

1. It is not advisable, at the present time, to establish in Canada a zinc smelter of the standard type.

The high cost of labour, fuel and supplies, handicaps any such smelter in Canada as compared with those in the United States. It might nevertheless be possible to smelt economically at a point like Medicine Hat where natural gas can be had at a normal charge, but the supply of zinc concentrates of sufficiently high grade is so limited that the plant could not operate economically even if no special difficulties were met in smelting the leady zinc ores of British Columbia. Further, such a smelter would only be able to utilize a small fraction of the zinc ores that are awaiting treatment, and it would seem more prudent to await the development, which cannot be far off, of a process that can handle the mixed ores as well as the high grade concentrates.

2. After reviewing and investigating a number of processes for the treatment of low grade and leady zinc ores, it appears probable that one or more of these may shortly attain to commercial success. The Trail Smelter where investigations of this nature are now being made, in view of its location and present equipment, would be a suitable place for treating the British Columbia zinc ores by such a process.

3. Encouragement should be given to any competent concern engaged in developing such a process, with a view to the production of zinc in Canada at the earliest possible time.

April, 1915. (Signed) ALFRED STANSFIELD.

SECTION II. VISIT TO THE TRAIL SMELTER.

7. *DISCUSSION ON ZINC SMELTING.*

Interview at Trail Smelter of the Consolidated Mining and Smelting Company, 5th April, 1915.

(Re-arranged from stenographer's notes and notes by Mr. Warren.)

There were present:—Mr. R. H. Stewart, General Manager of the Smelter; Mr. J. J. Warren, Director of the Company; Colonel David Carnegie; Dr. A. W. G. Wilson and Dr. A. Stansfield.

ZINC SMELTING IN BRITISH COLUMBIA.

The amount and character of the British Columbia zinc ores was discussed and the possibility of smelting these in a plant of the ordinary or Belgian type. It was pointed out that although there was a large amount of low grade and leady zinc ores the proportion of these that was suitable for smelting by the Belgian process was so small that it would hardly be possible to erect a Belgian smelter, especially in view of the high cost of labour and supplies in this country as compared with that in the zinc smelting localities of the United States. The possibility of producing zinc by electrolytic methods was also discussed. Experiments were in progress at the Trail plant and it was thought possible that these might be brought to a satisfactory conclusion and that a plant could be built at Trail for the economical production of zinc from a very large supply of low grade zinc ores available. The following points were brought out in the discussion:

1. SMELTING OF ORES IN BRITISH COLUMBIA BY THE BELGIAN PROCESS.

(*a*) *Supplies of Zinc Ores in British Columbia.*

These ores are not well suited to the Belgian process, being nearly all leady zinc ores with only a moderate percentage of zinc. There, are, however two or three mines in British Columbia that are rich in zinc and low in lead; in the Slocan district concentrates are produced containing 40-45% of zinc that could be smelted profitably at present prices. The ore

from the Standard Mine, in the Slocan, is very high in lime and this is unfavourable for the Belgian process. The Sullivan Mine can supply a very large amount of ore containing 30% of zinc. There is probably more of such ore in this mine than in any ten other mines in the country. It is now shipping to Trail 150 tons a day (50,000 tons a year) of lead zinc ore.

(*b*) *Present Utilization of British Columbia Zinc Ores.*

During the year ending 31st March, 1914, 10,000 tons of zinc ore and concentrates were shipped from Canada to smelting plants in the United States—such as those at Dupue, Ill.; Argentine, Kansas; Bartletsville, Okla., and Collinsville, Okla. The freight to Bartletsville is $10. per ton of ore. The duty on ore entering the United States has been 15% of the value of the zinc and 25% of the value of the lead in the ore when this was more than 3%; the duty at the present time is 10% on the value of the ore, less certain deductions.

In the case of a 45% zinc concentrate shipped into the United States the miner would receive $22 per ton less a cost of $15.70 per ton which is made up as follows:—

Freight	$10.00
Duty—10% on zinc content	4.95*
Duty—5% on lead content	0.75†
	$ 15.70

The miner thus gets $5.00 or $6.00 as a net return from the ore. A 45% concentrate, assuming a recovery of 85%, would yield 765 lbs. of zinc, which is worth at 5c per lb., $38.25. The probable cost of smelting this ore is about $10.00 a ton, so that the smelter receives $6.00 per ton in addition to the value of the lead which he receives for nothing, and 25% of the value of the silver content. The smelter pays the miner for 75% of the silver in the ore when this is over 6 oz. per ton. The British Columbia concentrates frequently contain from 25-30 oz. of silver per ton. It will be

* This has been calculated on the zinc content, 900 lbs. per ton, at 5½ cents per lb.; actually the duty is charged on the net value of the zinc content and is decidedly less than this figure. See Dr. Stansfield's Report.

† The duty charged is ¾ cent per lb. of lead on ores containing more than 3% of that metal.

seen that the miner receives an important return from the silver content in addition to what he may make on the zinc. It should also be noted that these concentrates were in a sense a by-product as the remainder of the ore, rich in lead, was sold to the Trail smelter for its contents of lead and silver.

(c) *Locations in British Columbia suitable for a Belgian Smelting Plant.*

In this connection it is necessary to consider: first, the supply of fuel, as nearly three tons of this is required per ton of ore treated; next the transportation of the ore from the mine, the transportation of the silver lead residues from the zinc smelter to a point at which they could be treated, and finally the transportation of the spelter to market.

At Medicine Hat natural gas would be available for heating the furnaces while coke, or coke and coal from Bankhead could be obtained cheaply for reducing purposes. The freight on the ore from the Slocan to Medicine Hat would be $4.00 per ton and from Kimberley to Medicine Hat $2.00 per ton. The cost of returning the residues to Trail should be set against the value of the lead in these residues.

At Lethbridge natural gas is available for heating furnaces, but trouble would probably be experienced over litigation with the neighbouring farmers.

While a Belgian plant at Medicine Hat would depend on ore containing from 40-45% of zinc, yet a lower grade ore containing say 30% of that metal would probably yield a small return when smelted at Medicine Hat, while a loss would be incurred by shipping it to the United States. One can therefore consider that if there was not enough 40% ore for operating a smelter the amount could be made up by additions of 30% ore keeping the mixture up to at least 35% of zinc.

At Fernie a zinc smelter could be operated economically with the aid of gas from the coke ovens. The coke produced by the Crowsnest Pass Coal Company only amounts to 60% of the coal treated; the balance of 40% being largely a gas which would be suitable and sufficient in amount for operating a zinc smelter. A plant at this point would be independent of the length of life of the gas wells about which there is always some uncertainty,

and the lead-silver residues could be shipped back more cheaply to Trail. Fernie is only 200 miles from Nelson while Medicine Hat is 440 miles from Nelson.

(*d*) *Cost of smelting Zinc Ores by the Belgian Process in Canada.*

At a point in British Columbia the smelting of one ton of zinc ore, using coal for fuel, would cost as follows:—

Mining	$ 1.50	per ton.
Transportation	2.00	"
Depreciation and interest	3.20	"
Administration	1.00	"
Repairs	1.00	"
Miscellaneous supplies	0.25	"
Clay—$\frac{1}{8}$ ton at $12.00 per ton	1.50	"
Coal—$2\frac{1}{2}$ tons at $3.50 per ton	7.00	"
Labour—$2\frac{1}{2}$ men per day at $3.50	8.75	"
	$26.70	per ton.

The tonnage of high-grade zinc concentrates produced in British Columbia at present is not sufficient to support a modern smelting plant. If such a plant were started it would have to depend on lower grade ores, of which a considerable tonnage is available. It may be assumed that the total tonnage of ore available would probably not average over 30% of zinc, or 600 lbs. to a ton. With an extraction of 75% only 450 lbs. of metal would be obtained, and at a price of 5·5 cents per lb. this would yield $24.75.

By the use of natural gas at some point like Medicine Hat the cost of smelting a ton of 30% zinc or would be as follows:—

Mining	$ 1.50	per ton.
Transportation	2.00	"
Depreciation and interest	2.00	"
Administration	1.00	"
Repairs	1.00	"
Miscellaneous supplies	0.25	"
Clay	1.00	"
Reduction material (anthracite)	1.50	"
Fuel	2.00	"
Labour	7.00	"
	$19.25	per ton.

It will be seen that in this case the cost of smelting a ton of ore is less than the value of the zinc to be produced. A further sum of $3.16 per ton should be allowed to cover the transportation of the spelter to markets in the east. It will be noted that it takes 4½ tons of ore to produce one ton of spelter.

It was stated that the cost of a Belgian plant for the treatment of fifty tons of ore daily, using coal as fuel, would be about $16.00 per yearly ton of ore, thus a 50 ton plant would cost about $300,000 in the United States, while in Canada about 25% additional should be allowed.

Crowsnest coal costs $2.00 per ton at the mine and $4.50 to $4.70 at Trail. Bankhead coal would cost $4.00 per ton at Medicine Hat. A culm from Bankhead costing from 75c to $1.00 at the mine, would cost nearly $3.00 at Medicine Hat, allowing $2.00 for freight.

Californian fuel oil can be purchased f.o.b. Trail at 85 cents per barrel, and 3½ barrels of this oil is equivalent to 1 ton of Vancouver Island coal. A plant at Trail would cost about $20.00 per ton of ore smelted yearly.

The Welsh Belgian zinc furnaces contains from 150-168 "pots" each. Each pot or retort holds 300 pounds of charge (ore and reducing coal). The retorts are 5 ft. long, 10 inches high and 8 inches wide inside, having a capacity of 2 cu. ft. In regard to smelting zinc ore by this process it was questioned whether a 45% concentrate could be smelted in Canada as profitably as in the United States, but it appeared that in the case of the lower grade ores the saving of freight might be relatively more important, and it was stated that if $400,000 were spent in erecting at Medicine Hat a 50 ton plant it should be possible to make a profit of $3.00 per ton on smelting 30% zinc ore when zinc was worth 5½ cents a lb.

II. *ELECTROLYTIC PRODUCTION OF ZINC.*

The management at Trail were doubtful whether such a process could be worked out successfully, but assuming that this could be accomplished it was calculated that the cost of the process would be as follows for a 30% zinc ore:—

Mining	$ 1.50	per ton.
Transportation	1.75	"
Roasting	2.00	"
Power at Trail	2.50	"
Leaching	0.50	"
Labour, etc.	2.10	"
Depreciation general	1.30	"
Depreciation specific on transformers	0.20	"
Transportation of spelter	2.50	"
	$14.35	per ton.

It was calculated that such a plant, having a capacity of 50 tons of ore per day, would cost from $150,000 to $200,000.

From the 30% ore, assuming an extraction of 70% there there would be a yield of 420 lbs. of spelter which at 5½ cents per lb. would bring in $23.10. This will leave a surplus of $8.75 from which, however, the interest and management charges must be deducted.

Mr. Stewart gave some account of their experiments with the French process, but said that good results were only obtained for the first twelve to twenty-four hours. They had spent $35,000 on these experiments, but were abandoning the process. They were now using what he described as the self-neutralization process this being satisfactory on account of the small amount of iron in the solution. They find that the deposit is better when a considerable amount of free acid is present. The voltage employed is about 4, ranging from 3½ to 4½, and the current density 30 amperes per square foot. The power consumption has been as low as 1½ to 1¾ KW. hours per lb. of zinc. The solution contains 15% of zinc and about 4% to 5% of free acid; the same process is in use by the Anaconda Copper Company. At Trail, power obtained from Bonnington Falls was stated to cost as much as $42 00 per h.p. year. The present capacity of the power plant is 24,000 h.p. of which Trail uses 6,000 h.p. On account of the small proportion of the power that is employed the charge made per h.p. year is high. Very much lower figures were mentioned as the probable cost if a large electrolytic plant were in operation. The power consumption for the electrolytic process amounts to about 150 KW. days or 200 h.p. days per ton of zinc.

Mr. Stewart stated that while there was not any large quantity of ore available for use by the Belgian process, there was an ample supply of ore containing 30% or more of zinc that could be treated by electrolysis. The cost of obtaining this ore from the Sullivan Mine would be \$1.50 per ton for mining and from \$1.60 to \$2.00 per ton for freight. Mr. Stewart considered that for the treatment of this ore the electrolytic process would be cheaper than the Belgian. Assuming the ore to contain 30% of zinc and the extraction to be 70% the yield of zinc would be 420 lbs. per ton of ore. This at $1\frac{3}{4}$ KW. hours per lb. would require 735 KW. hours, and charging \$20.00 per h.p. year (equal to 3/10ths of a cent per KW. hour) the cost of power would amount to \$2.50 for the treatment of one ton of this ore. This figure was assumed in the calculations with the understanding that power at Trail could be obtained at \$20.00 per h.p. hour. A plant for treating 50 tons of ore per day was stated to cost about \$200,000 which was about \$100 per h.p. The following items of cost were given with regard to the equipment of a plant for the treatment of 50 tons of ore per day. Such a plant would require 2000 h.p. Motor generators cost about \$15.00 per h.p. or \$35,000. A 1000 K.W. transformer from 60,000 volts would cost \$2,500, three of these would be required. A motor generator set of 1000-1200 K.W. would cost \$21,000. Switch equipment for three 1000 K.W. units would cost \$6,000. A roasting plant for treating 50 tons per day would cost \$5,000. The total arrived at was \$150,000. Depreciation and interest on this amounts to \$1.30 per ton.

Aluminium sheets were found to make the best cathodes.

The Watts process was mentioned, and it was stated that the solution could be kept neutral during electrolysis if zinc oxide were placed anywhere in the tank—in canvas bags for example. It was thought that large cathodes should be employed for this process. Trouble was experienced in the work from the formation of hydrogen and it was stated that if this could be removed the process would be very much more satisfactory. Mr. French used sulphurous acid as a depolarizer.

Unskilled labour at Trail costs \$3.00 a day and mechanics \$4.00 to \$4.50; the average cost for labour being about \$3.50.

III. *THE PRODUCTION OF ZINC OXIDE.*

Mr. Stewart spoke of the experiments which had been made in regard to separating zinc and lead from the ore in the form of a fume; using the Dedolph furnace they had been able to separate 60% of the lead and 8% of the zinc in the ore, and they were going to try whether with a larger amount of fuel it would be possible to remove the zinc as well as the lead. In this connection it was stated that no zinc was given off from the top of a lead blast furnace when using zincy ores. It was intended, if possible, to remove the zinc and lead from the ore and to smelt the residue by charging it into a copper converter. It was stated that sulphur in the ore could be driven off rapidly in a Bessemer converter.

IV. *MISCELLANEOUS.*

The electric smelting of zinc ores was mentioned. Mr. W. McA. Johnson had made a proposition to treat the ore, but needed too much assistance and could not guarantee satisfactory results. The possibility of obtaining zinc by electrolysis of the fused chloride was spoken of and it was stated that this would cost too much on account of the need of evaporating the solution.

The sulphite process of extracting zinc from its ore as operated at Swansea was described. The ore was roasted at a low temperature in a McDougal furnace provided with mufflers. The ore was placed in a tower and acted on by water and roaster gases yielding bisulphite of zinc.

The consumption of spelter in Canada was considered in the report by Dr. Stansfield, details of which are given.

2. DISCUSSION ON COPPER REFINING.

Interview at Trail Smelter of the Consolidated Mining and Smelting Company, 6th April, 1915.

(Re-arranged from stenographer's notes and notes by Mr. Warren.)

There were present:—Mr. R. H. Stewart, General Manager of the Smelter; Mr. J. J. Warren, Director of the Company; Colonel David Carnegie; Dr. A. W. G. Wilson and Dr. A. Stansfield.

COPPER REFINING IN BRITISH COLUMBIA.

The Company's officials were decidedly of the opinion that Trail was the best location for a copper refinery in view of the amount of copper ore and products available, the existing plant and experience of the staff. The following points were brought out in the discussion.

I. *LOCATION OF REFINERY.*

It was considered that the Trail plant was at the present time the best location for a copper refinery, especially in view of the fact that the copper produced on the Pacific Coast of British Columbia was obliged by contracts to be sent to the States for smelting or refining. If a refinery were now erected at Trail the possibility of operating it commercially would be demonstrated within a few years and by the time the contract for the Britannia output had expired it would be possible to start a second refinery on the Pacific Coast. The Consolidated Mining and Smelting Company are about to put in a converter plant to produce blister copper from their own matte. This copper will be so rich in gold and silver that it will be impossible to sample it accurately or to sell it at a profit to American refineries. The

Company will therefore be obliged to refine their own copper in any case, and it is desirable that the copper from surrounding districts should find its way to the Trail plant.

The copper matte made at Trail is worth from \$600-\$800 per ton for the gold and silver contents alone; the copper being 35% and the gold from 20-35 oz. per ton. Matte is sometimes shipped containing as much as 70-80 oz. of gold per ton, and an equal amount of silver. The saving by converting this matte to blister at the Trail plant instead of selling it amounts to $\frac{1}{2}$-$\frac{3}{4}$oz. of gold per ton.

At the Trail smelter there is in operation an electrolytic lead refinery costing about \$250,000 and having a capacity of eighty-five tons per day. This plant could be enlarged so as to handle a considerable tonnage of copper without materially increasing the overhead charges. The lead refinery also would serve to work up the slimes produced in the copper refining, and the combination of the copper and lead refining plants would thus result in a notable economy.

II. *SUPPLIES OF COPPER IN BRITISH COLUMBIA.*

It was stated that in the year ending March 31st, 1914, 45,000,000 lbs. of copper (in the form of ore, matte, or blister) was produced in British Columbia, of which 23,900,000 lbs. were produced in territory tributary to Tide Water, the remainder being east of the Cascades, and of the latter 16,400,000 lbs. were produced in the Boundary country, and 4,600,000 lbs. at Trail. It was stated that there is every probability that the copper production in the interior of British Columbia will increase very materially. There are, for example, very large deposits of copper in the British Columbia Copper Company's property. The latest available estimate was 6,000,000 tons of ore which should yield a net recovery of from 1-3% of copper.

There are 1,000 to 1,200 tons of copper ore coming daily from Rossland to the Trail smelter. The Granby smelter, about 100 miles away, is now smelting 2,500 tons of ore per day in six furnaces, their total equipment being eight furnaces with a capacity of 3,700 tons per day. It is expected that the matte made at Granby will be available for refining at Trail. In regard to the

re-melting of this material, it was stated that cold matte could be re-melted in the copper converters at Trail without any cost for fuel. Cold matte equal to 75% of the molten matte can be handled in this way.

III. *COPPER SMELTERS AND REFINERIES.*

At the present time there is no copper smelter in operation at the coast;* the Tyee Copper Smelter having been closed down. In the United States there is a refinery at Tacoma having a capacity of about twenty tons per day. The output of this refinery is however limited to the capacity of the western market for copper; the remainder of the copper being shipped in the crude form to Baltimore.

IV. *COST OF ELECTRIC REFINING AND PLANT.*

The cost of refining copper by electrolysis in the western part of the United States was stated to be $12.00 per ton, but at Great Falls, where the cost of power is nominal ($20.00 per h.p. year), it was estimated at $6.00 per ton. In eastern refineries, for an output of 200 tons a day or over, the cost was stated to be from $4.00 to $5.00 per ton, exclusive of overhead charges. It was stated that a plant for producing fifty tons of refined copper per day would cost $250,000 and that a plant for producing 100 tons per day would cost $450,000. These figures were understood to include the casting furnaces for anodes and cathodes. In an electrolytic refinery the copper undergoing treatment is tied up for about thirty days so that in a 50-ton plant some 1,500 tons of copper would constantly be in stock and this at 15c a lb. would be equivalent to $450,000 or for a 100 ton plant $900,000.

A refinery erected at Trail should cost somewhat less than the above figures in view of the existing lead refining and copper melting furnaces. It was stated also that the 85-ton lead refining plant at Trail which cost $250,000 was practically the same as a 50-ton copper refining plant. The overhead charges at Trail for superintendence would amount to 30 cents per ton on

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* There is, of course, the large new smelter at Anyox, on the Portland Canal.

account of the division of these amongst the different parts of the works. The overhead charges on the lead slimes plant is now $1.00 per ton of lead, and the expense for superintendence would not be increased if the plant were extended to include the treatment of the copper slimes. The present charges for labour in the tank room of the electrolytic lead plant were $1.50 per ton; the labour cost for the treatment of the slimes was $1.00 per ton of lead.

The amount of copper refined per K.W. hour varies from 7-9 lbs. Thus 192 lbs. of copper would be produced daily by 1 K.W. and 100,000 lbs (or 50 tons of copper) would be produced per day by 200 K.W. One ton of copper requires about 240 K.W. hours. The cost of power at Trail was stated to be $42.00 per h.p. year, at which figure the cost of power for refining a ton of copper only amounts to 85 cents. On this basis the estimated cost of refining copper at Trail in a 50 ton plant was as follows:—

Power	$ 0.85
Labour	2.50
Depreciation	2.05
Interest	1.46
Overhead Charges	0.30
	7.16

In the refining plant at Great Falls the melting furnaces cost about $2.00 per ton of copper for fuel, and with labour this amounts to $2.50 for remelting the copper.

V. *FREIGHT RATES.*

The following freight rates were given:—

From Trail to Montreal by rail	$11.00	per ton.
From Vancouver to Montreal by rail	10.00	"
From Great Falls to the East by rail	10.00	"
From Vancouver to Montreal via Panama	5.00	"
From Seattle to New York via Panama	4.50	"

It was stated that the shipment of blister copper to the east would be the same as that of the refined copper made from it.

3. ELECTROLYTIC COPPER REFINING.

Consolidated Mining and Smelting Company, Trail, B.C. April, 1915.

(A Series of questions asked by Dr. A. W. G. Wilson and answered by Mr. R. Stewart.)

A. 1. Q. Data re probable cost of refining of 50 tons daily capacity in—

(*a*) Trail, Power at $20.00 per K.W. year and coal at local rates.

(*b*) Eastern Canada, Power at $10.00 per K.W. year, coal at $4.00.

(*c*) Typical United States Plant.

A. (*a*) Probably $7.00 to $8.00 plus cost of refining slimes which in connection with present refinery would be very small.

(*b*) Probably $8.00 to $10.00, the difference being due to the fact that the refining of slimes, handling copper slags, melting anode bars and casting anodes, and general handling of by-products would require a separate operation, where in connection with the smelter they would cost but little.

(*c*) We believe from $6.00 to $10.00, according to to size, location and design of plant. Such costs are not readily available as they are in most cases kept secret by the companies operating the refineries.

2. Q. Auxiliary plant required and approximate capital costs.

A. The plant would consist of:—
- (a) Tank room.
- (b) Silver and gold refinery.
- (c) Refining furnace and casting machine and building.
- (d) Storage room for copper.
- (e) Melting furnace for anode bars scrap.
- (f) Boiler plant.
- (g) Motor generator and other electrical equipment.
- (h) Bluestone plant.
- (i) Repair shop.
- (j) Office and laboratory.
- (k) Scale house.
- (l) Sampling plant.

Probably $500,000 in West.
$400,000 in East.

Such a plant at Trail, operated in connection with the smelter and present plant, would omit (b), (d), (e), (f), (h), (i), (j) and (k), probable cost, $300,000 to $350,000.

3. Q. Operation of a 50 ton plant:—
- (a) Staff required (Technical, salaries)
  (Workmen, wages)
- (b) Power required.
- (c) Fuel required.
- (d) Raw materials and quantities.

A. (a) Difficult to get at off-hand. Technical staff at a separate operation necessarily much more expensive than in connection with smelter.
- (b) Power, say, 700 to 750 K.W.
- (c) Would depend on whether used in connection with smelter or whether by-product melting furnaces, etc., were a separate operation.
- (d) No very definite idea.

4. Q. Capital required:—
- (a) Plant construction.
- (b) Locked up in operation.
  - (I) Copper anodes and cathodes.
  - (II) Electrolyte.

(III) Gold and silver residues.
(IV) Copper in furnace slags and flue dust.
(V) Copper in residues.

(c) Interest charges per ton of ore per day.
(I) On capital in plant.
(II) On locked up material, including blister undergoing treatment.
(III) Depreciation.

A. Capital required:—

		Trail	East.
(a)	Plant as above...	$300,000-$350,000	$400,000
(b)	1. 30 days copper	$360,000	$450,000
	2.	$10,000	....

3. Impossible to estimate, being entirely dependent on gold and silver contents of blister approximately three weeks production of gold and silver.

4. and 5. If run in connection with smelter should be kept cleaned up. Say $10,000.

(c) 1 and 2. Interest charges at 6 per cent. per annum on above.

3. Depreciation on plant alone.

5. Q. Products of a 50 ton Electrolytic refinery per annum.
(a) Electrolytic copper.
(b) Gold and silver.
(c) Antimony and minor metals.
(d) Copper sulphate.
(e) Copper bearing slags.
(f) Copper scrap.

A. (a) Presumably fifty times 365.
(b) Impossible to guess at, depending altogether on contents of blister.
(c) Impossible to guess at, depending altogether on contents of blister. Probably not much to be recovered, at least, at first.
(d) ?
(e) ?
(f) Probably about 10% of production.

6. Q. Marketing of Products.
   (a) Location of markets.
   (b) Cost of marketing.
   (c) Present purchasers in Canada.

   A. This question can be best answered by the Department of Trade and Commerce.

7. Q. Utilization of Products:—
   (a) For manufacturers.
   (b) For agriculture.

   A. This question can be best answered by the Department of Trade and Commerce.

8. Q. How are such materials marketed?

   A. Don't understand to what the question refers.

B. Q. Advantages peculiar to Trail and the probable percentage saving in operation of a small unit at this point.

A. (1) No refinery would buy blister copper made from Trail matte on account of high gold value, say 60 to 100 ozs. per ton, on account of the difficulty of accurately sampling it. Hence, it is imperative that Trail blister be refined by the owners.

(2) Trail has now in operation a gold and silver refinery in which, with little capital expenditure, the additional slimes could be refined at very small extra cost.

(3) Trail has now in operation a bluestone plant in which further bluestone can be made, and a market for the production of such a plant.

(4) Copper slags and by-products, scrap, etc., can be handled in converters or blast furnaces now in operation or being installed, and will require little extra plant.

(5) Organization necessary is on the ground.

(6) Tank room can be handled in connection with electrolytic lead refinery now in operation, and with probably reduced cost on that account.

(7) Refinery up to, say, 15 tons can be operated in buildings already erected, with small additions for melting and casting refined copper.

(8) With the probability of electrolytic zinc the three electrolytic operations can be handled together with advantage.

(9) Trail would be a good point at which to collect blister copper from smelters in the interior of British Columbia for refining.

(10) The capital expenditure necessary for a small refinery at Trail would be less than at any other point owing to present refining operations.

(11) Power is developed and on the ground.

C. Q. In what form, if any, would you suggest assistance in the establishment of a zinc and copper refinery and in what way do you consider such assistance would react upon the manufacturers of the finished products of copper and zinc?

A. Suggest bounty or bonus per ton of copper refined in Canada for a period sufficient to establish the industry and to enable it to compete with larger refineries in the United States.

Copper is purchased practically in the open market and the market is immense, so that the effect on manufacrurers of finished articles would be negligible, duties on such articles would encourage manufacture. This applies also to zinc.

MISCELLANEOUS.

1. Q. Names and addresses of users of zinc, lead and copper in Canada?

A. Department of Trade and Commerce should have better information than ourselves.

2. Q. Exporters and consumers including European?

A. Department of Trade and Commerce should have better information than ourselves.

3. Q. Particulars regarding the qualities, amounts and location of the various copper ores in British Columbia?

A. Department of Mines.

4. Q. The influence of the Labour Unions upon the labour at Trail?

A. Labour Union usually well behaved with a tendency to increase wages at intervals. Branch of Western Federation of Miners.

5. Q. What influence do you think the refining of copper and zinc in Canada would have on the manufacturing industries of copper and zinc in Canada, the United States and Europe, and also upon the industries using copper and zinc?

A. None, unless it might encourage such industries in the West. Copper is, however, obtainable from Great Falls, Montana; and Tacoma, Washington, in the West, at freight rates similar to those which might obtain from Trail.

6. Q. Would the establishment of a refinery for copper and zinc in Canada create unhealthy competition between the United States and Canada and thus reduce the price of copper and zinc and make it unprofitable for Canada to continue refining by reason of the smaller output?

A. Canadian copper production will need to grow considerably before it is even noticeable.

7. Q. What is the comparative cost of living in the mining and smelting districts in the United States compared with the same districts in Canada?

A. I believe probably from 15% to 40% lower in United States, according to location.

8. Q. What are the comparative labour costs of the mining, smelting and refining in the Unites States and Canada?

A. Wages are from 15% to 30% higher in Canadian smelters than in the United States. Wages for common labour as much as 100% higher than in Southwestern States.

9. Q. What is the probable amount of business with the United Kingdom in copper and zinc?

A. In zinc, none. Copper depends on output,—no means of ascertaining.

10. Q. What finished products in copper and zinc do you consider as a manufacturing adjunct to the smelters?

A. None, except refined metals, unless some special market should develop.

11. Q. What by-products from the smelter could be utilized for economical purposes?

A. Don't understand how much is meant by the question. Depends on the markets available. Most probable available by-products would be arsenic, antimony and bluestone, and *sulphuric acid, if the market justified.

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* A sulphuric acid plant has since been established at the works of the Consolidated Mining and Smelting Co., Limited, at Trail, B.C.

ZINC SMELTING AND OTHER EXTRACTION PROCESSES.

Consolidated Mining and Smelting Company, Trail, B.C., April, 1915

A series of questions asked by Dr. A. Stansfield and answered by Mr. R. Stewart.

BELGIAN PROCESS FOR TREATING ZINC ORES.

1. Q. Data *re* probable cost of a Belgian Retort Plant for treating 50 tons daily of 35% zinc ore in Canada?
   (a) Capital required for Plant construction.
      (I) Roasters.
      (II) Distillation Furnaces.
      (III) Retort making plant and other auxiliary equipment.
   (b) Capital required for operation (including stock and supplies).
2. Q. Approximate cost of operating such a plant at:—
   (a) Fernie, B.C., using excess gas from a by-product coking plant.
   (b) Fernie, B.C., using local coal and regenerative firing.
   (c) Medicine Hat, Alta., using natural gas at 2c per 1000 cu. ft. (1100 B.T.U.).
3. Q. Operations of a 50-ton Belgian plant at places indicated?
   (a) Staff required, technical, salaries; workmen, wages.
   (b) Power required and costs.
   (c) Fuel required and costs.
      (I) Roasting.
      (II) Reducing.
      (III) Retorting.
   (d) Raw material and quantities,
      (I) Ores.
      (II) Clay.
      (III) Sundries.

A. Regarding the BELGIAN PROCESS FOR TREATING ZINC ORES:— I told Dr. Stansfield at the time he was here I had no very definite information on the subject,— Dr. Stansfield's figures were as accurate as any that I could possibly obtain in this part of the country where there is no zinc smelting.

It will be possible, if the Government actually intends to put in a plant for the smelting of zinc, or to assist in the putting in of a plant for the recovery of zinc, to get the necessary information and apply it to the different places where zinc smelting might be practiced in Western Canada, and then to make estimates of the cost of building and operating such a plant, but this will involve a considerable expenditure of time and money. In the meantime, Dr. Stansfield's own figures, obtained from Mr. Ingalls and others, are probably as accurate as can readily be obtained.

With regards to questions 1, 2, and 3, we have no information which would enable us to give intelligent answers to these three questions.

4. Q. Data *re* probable available supply of zinc ores from B.C. Mines?

A. Mr. Turnbull has given Dr. Stansfield an estimate of the probable available tonnage of some of the mines. Without an exhaustive examination of the mines, which are not owned by this Company, and whose owner's permission would be required to make such examination, it is impossible to give any intelligent estimate as the owners themselves have not, as a rule, any idea of the probable tonnage of ore available, and are very loath to give out the information.

5. Q. Information in regard to special difficulties or increased costs likely to be encountered in treating the B.C. ores by this process, as compared with the ores treated in Kansas Zinc Smelting Plants?

A. As we have had no experience in the smelting of zinc ores, we are not informed as to this question, except as to the matter of labour, which, in British Columbia, would be probably 30% to 40% higher than in Kansas plants.

6. Q. Freight charges for moving materials?
   (a) Zinc ores from B.C. mines to Fernie.
   (b) Zinc ores from B.C. mines to Medicine Hat.
   (c) Retort residues from Fernie to Trail.
   (d) Retort residues from Medicine Hat to Trail.
   (e) Spelter from point of production to market (Montreal and Sydney)?

A. Mr. W. R. MacInnes, General Freight Manager, Canadian Pacific Railway, Montreal, would be the most likely person to give you accurate information on this point. Commodity rates are very variable and there is no logical basis on which one can predict any rate. We believe rates might be as follows:—

Rates on	*From*	*To*	*Probably*
Zinc ores	B.C. Mines	Fernie	\$2.00 to \$2.50
Zinc ores	B.C. Mines	Medicine Hat	\$3.00 to \$2.50
Retort residues	Fernie	Trail	\$2.00
Retort residues	Medicine Hat	Trail	\$3.00 to \$4.00
Spelter	Fernie	Montreal	\$12.00
Spelter	Fernie	Sydney	\$14.00
Spelter	Medicine Hat	Montreal	\$10.00
Spelter	Medicine Hat	Sydney	\$12.00

7. Q. Treatment charges as follows:—
   (a) Cost of smelting retort residues at the zinc plant at the points mentioned?
   (b) Treatment charges on retort residues at Trail?

A. As to the cost of smelting retort residues, I am not very well informed. I would refer you to two paragraphs in the Report of the Zinc Commission, Mines Branch of the Interior, for 1906, referring to the smelting of such products, which appears to show that the smelting of these residues at a zinc smelter is unprofitable, whereas, where residues are shipped to a lead smelter they can be treated at a moderate rate. (Copy attached)*

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*Extract from the Report of the Zinc Commission, Mines Branch of the Interior, for the year 1906; page 35.

"At Iola, Kan., the smelting of retort residue containing 10 to 16oz. silver, 0·03oz. gold, and about 6% lead, was abandoned as unprofitable after a long trial, although 91% of the silver, 92·5% of the gold and 92% of the lead were

8. Q. Probable recoveries of zinc, lead and silver by such a process?

A. Recoveries of zinc are, as I understand, from 75% to 81%, and recoveries of lead and silver are, I believe, high, although the operators of zinc smelters are not in the habit of publishing their recoveries.

TREATMENT OF LEADY ZINC ORES

1. Q. What process, if any, could you recommend as being:—

(*a*) Definitely known to be suitable for the economical treatment of low grade and mixed lead ores of B.C., such as the Sullivan ores.

(*b*) Probably suitable for this purpose.

A. I know of no process which is at present in operation for the treatment of ores of this nature, and, therefore, there is no process which I could recommend for anything more than experimental work. I may say, however, that we are now producing about 500 lbs., daily, of zinc spelter, electrolytically, with about 1.8 kilowatt hours per pound of zinc, which power consumption can probably be reduced very considerably in a plant working under normal conditions, and I am in hopes that as the process has developed so far it may still further develop within a short period of time.

2. Q. What action, if any, on the part of the Government in your opinion would help to accelerate:—

(*a*) The completion of necessary experimental work, leading to the development of a satisfactory process.

(*b*) The establishment at Trail, or elsewhere, of a plant for treating these ores and producing zinc in Canada.

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recovered. It may be assumed, therefore, that the cost of smelting was considerably in excess of $10.00 per ton.

"On the other hand, in a very favourable location, such as Pueblo, Colo., where there are silver-lead smelters treating an immense tonnage of ore, with which the zinc residue can be advantageously mixed in comparatively small proportion, the cost of smelting it may be quite moderate, say $5.00 per ton."

A. (*a*) As to what action on the part of the Government would help to accelerate the completion of necessary experimental work,—I am not sure that any action of the Government can complete necessary experimental work, as there are sufficient inducements for the completion of any process which will satisfactorily treat leady zinc ores, due to the fact that there are such ores, to be found in every country of the world, which have been waiting for such a process for many years; and there are now a great many of the larger metallurgical companies using their best endeavours to find such a process and who would be only too glad to take up any such process if it had the appearance of being feasible.

(*b*) In order that a successful plant may be established at Trail, or in any part of the Dominion of Canada, for the treatment of such ores, it is necessary that such plant compete with established plants producing zinc in the United States and elsewhere; and, owing to the general higher costs of labour and supplies, due to the Customs Tariff; and to generally higher rates of wages, it would be necessary for the producer of spelter to receive greater returns for his spelter than in the United States or Europe. It would appear, therefore, that to offer inducements towards the establishment of the industry in Canada it would be necessary for the Government to either—

(*a*) Agree to place a protective tariff on zinc and zinc products,—galvanized iron and all manufactures of zinc, such as, brass which could be manufactured in Canada, or,

(*b*) Pay a bonus on all zinc manufactured in Canada, until such time as a tariff on zinc and zinc products could be applied, or until such a time as the production of zinc in Canada would justify the imposition of a tariff on zinc and zinc products.

Such bonus, or royalty, should tend to equalize the differences in the cost of manufacture in Canada and elsewhere. If this were no inducement to the establishment of the zinc smelting industry in Canada, it

would appear that the time was not yet ripe for the establishment of such an industry.

TREATMENT OF MIXED ORES BY ROASTING TO SULPHATE, LEACHING WITH SULPHURIC ACID AND ELECTROLYSIS OF THE SULPHATE SOLUTIONS.

1. Q. Technical details of the experimental results obtained?

A. As most of the experimental work with which we are acquainted in this direction is being conducted by private enterprise, the details are more or less private property, and have generally been obtained confidentially, so that it would seem to be out of the question to make any statement as to such details. As our to own work, we are obtaining, as I said before, 500 lbs. of spelter per day with a current expenditure of 1.8 kilowatt hours per pound of zinc. As to the details for which Dr. Stansfield asks,—most of them have yet to be worked out; as in our preliminary work we have considered that the most important point was to find out whether we could produce the spelter continuously with a reasonable power consumption.

The roasting so far has been carried on in the ordinary manner in the Wedge furnaces at a comparatively low temperature, and no very particular attention has been paid to the recoveries possible by leaching, except that some experimental results have given as high as 75% to 80% extraction of zinc from the ores. The amount of acid used per ton has not been determined, and is liable to vary very considerably, according to conditions under which the ore is roasted, and this will only be determined by operations on a larger scale.

The particulars of the electrolytic process, I hardly feel at liberty to give at present, as they are not definitely worked out and are more or less private property. The essential feature of the operation will naturally be the final cost of producing one ton of spelter, and until definite plans for the arrangement of a refinery; the handling of materials; the method of leaching on a large

scale, and the disposition of the residues are determined, it will be impossible to make any intelligent estimate.

2. Q. What difficulties, if any, stand in the way of the immediate use of the process, for the commercial production of spelter from British Columbia ores?

3. Q. In the event of any such difficulties being overcome:—
   (*a*) What would be the cost of erecting at Trail, the plant necessary for treating by this process, 50 tons daily of these ores?
   (*b*) What would be the cost of operating this process?

A. In view of the fact that the process as used here is in such an infantile state, it is impossible to give answers to questions 2 and 3, the power cost being the only thing definite about the process.

FURNACE CONCENTRATION PROCESS.

1. Q. Do you know of any suitable process for treating the B.C. leady-zinc ores, so as to obtain the zinc and lead in the condition of a fume (metallic or oxidized):—
   (*a*) Leaving a slagged residue to be treated for the silver contents?
   (*b*) Leaving a clean slag and a matte or bullion carrying the silver?

A. There are probably several experimental processes which *might* possibly produce the desire results, but we know of no process which could, at present, be recommended to produce it.

2. Q. What would be:—
   (*a*) The cost of such a process?
   (*b*) The nature and composition of the fume?
   (*c*) The recovery of the zinc and lead?
   (*d*) The distribution of the silver between the fume and the residue?
   (*e*) The cost of recovering the silver from the residue?

A. As these processes are apparently in a very experimental stage, we can form no idea as to the costs of operation, or the recoveries. We presume that the composition of the fumes would be combined lead and zinc oxides

and sulphates. There would probably be a considerable amount of silver carried over with the fume as long as there was much zinc carried over. The cost of recovering the silver from the residue would probably be the cost of smelting the residue and producing a copper matte carrying the silver, and then refining the copper matte, or, of smelting the residues in a blast furnace with the lead fume and recovering the silver by means of the lead. The costs would naturally depend very much on the nature of the operations and could not be estimated unless the process were laid down definitely.

3\. Q. Would any of the following processes be suitable for the above purpose?

(*a*) Roasting in Wedge Furnace and blowing on Wetherill grate?

(*b*) Treatment of raw or roasted ore by the Dedolph process?

(*c*) Roasting in Wedge Furnace and Dwight Lloyd Roaster and smelting in blast furnace with ample fuel and hot top for the volatilization of the zinc and lead?*

(*d*) Production of metallic zinc fume by smelting the roasted ore in a blast furnace by the Hempel process. (Ingall's Zinc, 1906 ed., p. 658). This metallic fume to be used in anode cells of the Watts process where it would act to some extent as a soluble anode, reducing the voltage and preventing polarization?

A. (*a*) Roasting in Wedge furnace and blowing on Wetherill grate would, we believe, extract the lead and the greater part of the zinc from the residue, leaving the zinc and lead fume to be separated by leaching, or some such process, and electrolyzed. The feasibility of the process would depend on the cost of the fuel for the Wetherill grate, and the efficiency of the extraction of zinc, and we are not in a position, without experimenting, to give any decision on the subject.

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*Compare Bartlett process (Hofman's Lead, p. 142) and Ellershausen process (Ingall's Zinc, 1906 ed., p. 665).

(*b*) The same question applies to the Dedolph process.

(*c*) Sounds like a cheap way to get rid of the lead, but as to its efficiency in volatilizing the zinc I am a little doubtful. Presumably the fumes could be collected by the Cottrell process or a bag-house, much of the zinc being fumed; our experience with blast furnaces, even with hot tops, has been that a very little of the zinc goes up the stack. If the efficiency is good, the process sounds as if it might be a cheap way of fuming the zinc, but the combined lead and zinc fume would have to be leached to separate the zinc and lead afterwards.

It appears to us that the only way to make a success of any of these processes would be to try them and determine the cost by actual experiment. It is very difficult to form any opinion without actual experimentation. While some of the processes sound nice on paper, they have unexpected ways of surprising one when they are carried out in practice.

WATTS ELECTROLYTIC PROCESS.

1\. Q. Does this process appear to you to be practicable on a commercial scale?

(*a*) For use with roasted B.C. ores?

(*b*) For use with zinc or zinc-lead fume produced as in previous sections of these notes?

A. Provided it is possible to find a container for the zinc oxide or ore to be leached, and a reasonable way of charging the container, and discharging it, the process might be worked out, although the handling of the ore in such small units as the anodes would probably be, would be apt to be costly in operation. If some special form of anode can be devised which would do away with this objection the process might be worked out, though it seems to us that roasting the ores, leaching and electrolyzing, is likely to prove the simplest process.

2\. Q. Could you give some idea of the probable cost:—

(*a*) Of the plant?

(*b*) Of the operating expenses including the recovery of lead and silver from the residue?

A. I have no idea what the probable cost of building or operating the plant would be. This could probably be better estimated by the inventor.

OTHER PROCESSES FOR TREATING LEAD-ZINC ORES.

1\. Q. What is your opinion of the following processes, as regards their applicability to the B.C. ores, their efficiency in recovering the metallic values and the cost of operating them?

(*a*) Bisulphite process (Met. and Chem. Eng. Vol. XI, 1913. p. 531).

(*b*) Dry chlorination process (Malm process) (Met. and Chem. Eng. Vol. IX, 1913. p. 159).

(*c*) Swinburne and Ashcroft chlorine smelting process (Mineral Industries, vols. X and XI).

(*d*) Roast to zinc sulphate, leach with sulphuric acid, evaporate to dryness and roast to zinc oxide, reduce to zinc by the Watts process?

(*e*) Bretherton process of leaching with ammonia and CO_2. (Amer. Inst. Min. Eng. XLVII, 1913).

A. (*a*) *Bisulphite process* is probably one of the simplest processes that has been devised, makes use of no chemicals, the leaching material being the gas produced by the roasting furnace, and the whole process has been well thought out. I have no idea, however, of what recoveries have been made by using this process. I understand that a hundred-ton plant was erected in Tasmania, but have never heard that it was successful. Whether the recoveries are good or not, I am unable to say. We have the statements of the inventor that from 75% to 80% recovery was made on Sullivan ore, but as to whether this could be obtained in regular practice, I am unable to say.

(*b*) *Malm process.*—I think this process has been tried out in some of the mines in the Coeur d'Alenes, Idaho, but do not believe it has been a success so far.

(*c*) *Swinburne and Ashcroft chlorine smelting process.*—I am unable to give an opinion on this process.

(*d*) As it seems to be possible to produce zinc direct from the sulphuric acid leach, it would seem that the cost of the evaporating to dryness and roasting to zinc oxide, were two extra operations, which would be comparatively costly and would not reduce the cost of electrolyzing sufficiently to pay for the extra operations.

(*e*) *Bretherton process.*—I have not heard of any results obtained with this process.

ROASTING AND OTHER OPERATIONS.

1. Q. For assistance in estimating the cost of various processes please state:—approximate cost of plant and operating cost for the following as used at Trail:—

(*a*) Wedge Roaster?
(*b*) Dwight Lloyd Roaster?
(*c*) H. and H. Roaster?
(*d*) Godfrey Roaster?
(*e*) Cottrell process?
(*f*) Smelting ores in lead blast furnaces?
(*g*) Betts process for lead refining?

A. (*a*) *Wedge Roaster.*—A $22\frac{1}{2}$ ft. Wedge roaster, as erected at Trail, 7 hearth, will cost from $20,000 to $25,000 according to the frills that are put on it. Such a roaster has a capacity for pre-roasting Sullivan ore of about 90 tons per day, and, I believe, a capacity of from 40 to 50 tons for leaching, but this is more or less indefinite. Cost of operations will depend upon how much fuel is necessary to use to get rid of the last of the sulphur, and will vary from 50c to 80c per ton, or if the tonnage is low, it may be considerably more.

(*b*) *Dwight and Lloyd Roaster.*—These plants are operated on royalty. The operating cost of these, including royalty, will probably be in the neighbourhood of 75c per ton, but I do not think that they are valuable for roasting for any of the processes mentioned above, without considerable assistance from other roasters or rolls.

(*c*) *H. and H. Roaster.*—Each pot costs about $7000. A plant consisting of 36 pots, crane and crusher plant, cost us in the neighborhood of $100,000. The operating cost varies from 80c to 90c per ton.

(*d*) *Godfrey Roaster.*—A Godfrey roaster costs about $7,000.00, but is only suitable for pre-roasting ore, and even then it uses an inordinate amount of fuel. Cost of operating these roasters on Sullivan ore, for pre-roasting purposes is about $1.50 to $1.60 per ton.

(*e*) *Cottrell Process.*—A Cottrell plant for handling 100,000 ft. of gas per minute will probably cost from $30,000.00 to $50,000.00 according to the design of the plant and the purpose for which it is to be used. The cost of operation is low, but the rights to the use of the process have to be paid for or royalty paid on the net production. The only attendance required is that of one man per shift to look after the electrical apparatus and make slight repairs, and one or two men to clean up the product, according to the arrangement of the plant below.

(*f*) *Smelting ores in lead blast furnaces.*—This depends entirely on the class of ores to be smelted and may vary from $2.50 to $6.00 and even $7.00 per ton, but the recoveries in lead smelting play such an important part in the final result of the plant's operation, that the mere figures of costs of blast furnace smelting and roasting do not necessarily give any idea as to the result to be expected from the smelter.

MARKETING OF PRODUCTS.

1. Q. (*a*) Location and size of markets for zinc, lead and silver?

(*b*) Cost of marketing these materials?

(*c*) Present purchasers in Canada and Great Britain?

A. (*a*) As to the location and size of markets for zinc, lead and silver, I would refer you to "Metal Statistics," a yearly publication of the American Metal Market Company, 81 Fulton Street, New York, which contains all this information in a very compact form. This book is published every year and you can obtain

it by writing to them. In the meantime we are forwarding a copy under separate cover.

(*b*) Cost of marketing these materials—we do not understand what you mean by the cost of marketing. We have never marketed any zinc, so do not know very much about it.

Lead.—We presume that the cost of marketing is the freight from Trail to the market, plus whatever commissions we pay to our agents, and insurance where such is necessary. In general, the freight rate from Trail to all points from Calgary, east, is $12.00 per ton, and to the Maritime Provinces, $14.00 per ton.

Silver.—Silver is a metal which is marketed by bids from purchasers of silver, such as banks trading in the Orient, and sundry well known brokers, such as Messrs. Handy and Harmon, New York. The cost of transportation per ounce is comparatively small, as silver is usually shipped by express and is not bulky, so that, in addition, marketing from Trail has sometimes the advanage that it is closer to the Orient than New York, and there may be, in consequence, a price obtained for silver in Trail that could not be obtained if the refinery were situated in New York.

(*c*) *Present purchasers in Canada and Great Britain.*—We do not know whether you refer to present purchasers of our products in Canada and Great Britain, or not. We sell no metals in Great Britain. Lead is sold in Canada to wholesalers in Montreal, Toronto, and various Eastern points, such as,—

Thomas Robertson & Co.,
Brandram, Henderson Co.,
Sherwin-Williams Paint Co.,
Dominion Wire and Cable Co.,
Standard Underground Cable Co.,
James Robertson Co.,
Canadian Metal Company,
Robertson-Godson Company,

and a large number of smaller purchasers.

Silver, we sell to,—

Messrs. Handy and Harmon, New York,
Anglo and London Paris National Bank, San Francisco,
Hong Kong and Shanghai Banking Corporation, New York,
International Banking Corporation, San Francisco,

whichever will give us the best price for it.

CONSOLIDATED MINING AND SMELTING COMPANY OF CANADA, LIMITED

Wage Scale, Smelter. *Corrected to July 1st, 1916*

		*First Scale	†Second Scale	‡Third Scale
Copper Furnaces—				
Furnaceman	8 hours	$4.00	$4.25	$4.40
Feeder	8 "	4.00	4.25	4.40
Loader or 2nd Feeder	8 "	3.50	3.75	3.90
Pot Pullers	8 "	3.50	3.75	3.90
Slag Spout Man	8 "	3.00	3.25	4.30
Clay Man	8 "	3.00	3.25	3.40
Feed Floor Sweeper	8 "	3.00	3.25	3.40
Flue Dust Man	8 "	3.00	3.25	3.40
Craneman	8 "	3.65	3.90	4.05
Labourers	8 "	2.75	3.00	3.15
Dump Switchmen	8 "	3.00	3.25	3.40
Tapper	8 "	3.50	3.75	3.90
Lead Furnaces—				
Furnaceman	8 hours	$4.00	$4.25	$4.40
Feeder	8 "	4.00	4.25	4.40
Loader	8 "	3.25	3.50	3.65
Slag Tapper	8 "	3.50	3.75	3.90
Slag Spout Man	8 "	3.25	3.50	3.65
Bullion Men	8 "	3.00	3.25	3.40
Flue Dust Men	8 "	3.00	3.25	3.40
Cranemen	8 "	3.65	3.90	4.05
Crane Chaser	8 "	3.00	3.25	3.40
Labourers	8 "	2.75	3.00	3.15
Feed Floor Sweeper	8 "	3.00	3.25	3.40
Casting Lead Anodes—				
Lead Caster	8 hours	$3.25	$3.50	$3.65
Slag Breaker—				
Operator	8 hours	$3.25	$3.50	$3.65
Helper	8 "	3.00	3.25	3.40

*First Scale.—Scale in force, April 30th, 1916.

†Second Scale.—War Scale to go into effect May 1st, 1916, and to continue in force for the duration of the war, unless the prices of metals drop sufficiently to lower the mine scales when 50% of the reduction made in either or both the lead or copper scales will be made on the smelter scale.

‡Third Scale.—This scale became effective July 1st, 1916, for July, August and September, a flat increase of 15c per man per day on the second scale; this increase to continue in effect as long as copper remains above 25c Montreal and lead remains above 8c Montreal. When copper is between 22c and 25c and lead between 7c and 8c, this increase will be 10c per man per day, and when copper is between 18c and 22c and lead is between 6c and 7c, this increase will be 5c per man per day.

		First Scale	Second Scale	Third Scale
Matte Plant—				
Crusherman	8 hours	$3.25	$3.50	$3.65
Wheeling to Crusher	8 "	3.00	3.25	3.40
"Dumper" Kilker Cars	8 "	3.00	3.25	3.40
Labourers	8 "	2.75	3.00	3.15
H. & H. Roasters—				
Firemen	8 hours	$3.50	$3.75	$3.90
Converter Tender	8 "	3.00	3.25	3.40
Converter Crane Chaser	8 "	3.25	3.50	3.65
Converter Helpers	8 "	2.75	3.00	3.15
Ore Wheelers	8 "	2.75	3.00	3.15
Crusherman	8 "	3.25	3.50	3.65
Crusherman Helper	8 "	3.00	3.25	3.40
Scaleman	8 "	3.00	3.25	3.40
Labourers	8 "	2.75	3.00	3.15
Craneman	8 "	3.65	3.90	4.05
Hoistman	8 "	3.25	3.50	3.65
Wedge Roasters—				
Furnacemen	8 hours	$4.00	$4.25	$4.40
Scaleman	8 "	3.00	3.25	3.40
Labourers	8 "	2.75	3.00	3.15
Dwight and Lloyd Roasters—				
Furnacemen	8 hours	$4.00	$4.25	$4.40
Helper	8 "	3.00	3.25	3.40
Labourers	8 "	2.75	3.00	3.15
Sample Mill—Day—				
Millwright	8 hours	$4.50	$4.75	$4.90
Millman, Head	8 "	3.50	3.75	3.90
Millmen	8 "	3.00	3.25	3.40
Labourers	8 "	2.75	3.00	3.15
Crusherman	8 "	3.00	3.25	3.40
Sample Cutter	8 "	3.50	3.75	3.90
Cottrell Plant—				
Operator	8 hours	$3.50	$3.75	$3.90
Handling Fume	8 "	3.00	3.25	3.40
Sample Mill—Night—				
Foreman	8 hours	$4.00	$4.25	$4.40
Millmen	8 "	3.00	3.25	3.40
Crusherman	8 "	3.00	3.25	3.40
Labourers	8 "	2.75	3.00	3.15

	Hours	First Scale	Second Scale	Third Scale
Mechanical Department—				
Foreman Machine Shop	9 hours	$5.00	$5.25	$5.40
Foreman Boilermaker..	9 "	5.00	5.25	5.40
Machinists...........	9 "	4.00 to 4.50	4.25 to 4.75	4.40 to 4.90
Machinists' Helpers...	9 "	3.00 to 3.25	3.25 to 3.50	3.40 to 3.65
Boilermakers.........	9 "	4.00	4.25	4.40
Boilermakers' Helpers.	9 "	3.00	3.25	3.40
Flanger.............	9 "	4.25	4.50	4.65
Flangers' Helpers.....	9 "	3.25	3.50	3.65
Welder..............	9 "	4.00	4.25	4.40
Welder's Helper......	9 "	3.00	3.25	3.40
Blacksmiths..........	9 "	4.00 to 4.50	4.25 to 4.75	4.40 to 4.90
Blacksmiths' Helper...	9 "	3.25	3.50	3.65
Car Repairers........	9 "	3.25 to 3.50	3.50 to 3.75	3.65 to 3.90
Drillers..............	9 "	3.25	3.50	3.65
Pipe Fitters..........	9 "	3.50 to 4.50	3.75 to 4.75	3.90 to 4.90
Pipe Fitters' Helpers..	9 "	3.00 to 3.50	3.25 to 3.75	3.40 to 3.90
Chain Gang Foreman..	9 "	4.50	4.75	4.90
Chain Gang Labourers.	9 "	2.75 to 3.00	3.00 to 3.25	3.15 to 3.40
Blower Room Tender..	8 "	4.00	4.25	4.40
Oilers...............	8 "	3.25	3.50	3.65
Labourers............	9 "	2.75	3.00	3.75
Masons—				
Bricklayers...........	9 hours	5.00	5.25	5.40
Bricklayers' Helpers...	9 "	3.00	3.25	3.40
Labourers............	9 "	2.75	3.00	3.15
Refineries.—				
Short Circuit Men, Tank-room F'man.........	8 hours	$3.50	$3.75	$3.90
Tankroom Labour.....	8 "	2.75	3.00	3.15
S. Circuit Men, Helpers.	8 "	2.75	3.00	3.15
Sheet Hanger..........	8 "	3.00	3.25	3.40
Sheet Hanger Helpers...	8 "	2.75	3.00	3.15
Sheet Hanger Boys.....	8 "	1.75	2.00	2.15
Sheet Caster..........	8 "	2.75	3.00	3.15
Shift Bosses, Slimes Plant	8 "	3.50	3.75	3.90
Parters and Furnacemen (Slime)..............	8 "	3.00	3.25	3.40
Slimes Roasterman.....	8 "	2.75	3.00	3.15
Motor Tender.........	8 "	3.50	3.75	3.90
All Labour............	8 "	2.75	3.00	3.15
Cranemen.............	8 "	3.25	3.50	3.65
Crane Chasers.........	8 "	3.00	3.25	3.40
Scrap Washers.........	8 "	3.00	3.25	3.40
Vitriol Plant Men......	9 "	3.00	3.25	3.40
Vitriol Plant Labour...	9 "	2.75	3.00	3.15
Machinist & Pipe Fitter	9 "	4.00	4.25	4.40

Slime Wash (Contract) at $3.75 day

		First Scale	Second Scale	Third Scale
Electrical Department—				
Electricians..........	9 hours	3.50 to 4.50	3.75 to 4.75	3.90 to 4.90
Electricians' Helpers...	9 "	3.00	3.25	3.40
Labourers............	9 "	2.75	3.00	3.15
Linemen.............	9 "	3.50	3.75	3.90
Motormen...........	8-9 "	3.25	3.50	3.65
Carpenters—				
Carpenters...........	9 hours	4.00 to 4.50	4.25 to 4.75	4.40 to 4.90
Carpenters' Helpers...	9 "	3.00	3.25	3.40
Labourers............	9 "	2.75	3.00	3.15
Track Layers.........	9 "	3.50	3.75	3.90
Track Layers' Helpers.	9 "	3.00	3.25	3.40
Flume Foreman.......	9 "	4.00	4.25	4.40
Flume Watchman.....	12 "	3.00	3.25	3.40
Teamster............	9 "	3.25	3.50	3.65

6. SMELTING CHARGES IN BRITISH COLUMBIA.

1. SMELTER RATES ON COPPER, LEAD, GOLD AND SILVER, TRAIL SMELTER, 1912.*

Treatment rates vary widely on different classes of ore. The practice is to quote rates f.o.b. the smelter as far as possible, making them independent of variable freight rates.

The lowest treatment rate is $1.50 per ton on low-grade easily smelted, self-fluxing Boundary ores. Rossland siliceous copper ores receive a $3.00 rate, and other copper ores receive rates not far from this, depending on quantity and quality. Indirect deductions are usually about 0.4% from the copper wet assay, and 4 cents per pound from the New York price. The location of the smelter making marketing costs comparatively high, 95% of the gold and silver is paid for at $20.00 per ounce for the gold, and New York quotations for the silver.

Lead sulphide ores are treated on a basis of $8.50 to $9.50 per ton for ore carrying 70% lead, adding 10 cents per unit for each per cent under 70, to a maximum of $10.50 to $11.50. The lower are contract and the higher are open rates. 90% of the lead fire-assay is paid for, if over 5%, at London, England, quotations less 1 cent per pound marketing charge. 95% of the gold and silver is paid for as above. Settlements are usually based on quotations 3 months from date of receipt of ore in the works.

Dry ores, iron concentrates, etc., receive a variety of rates, usually based on a $3.50 to $4.50 treatment rate with sliding scales. Excess iron is allowed for and excess silica is penalized at 7 cents per unit. Sulphur in siliceous or oxidized lead ores is penalized at 50 cents per unit. Zinc in all ores is penalized 50 cents per unit for each unit over 8 per cent.

2. SMELTER RATES, COPPER, TYEE SMELTER, 1912.*

Smelting charges.—Payment was made for copper contents, wet assay less 1.0% at New York quotations for electrolytic

*These rates are representative of rates which prevailed in normal times. Present rates are higher.

copper, less 3 cents per pound; gold, if over 0.02 ounces per ton, at \$19.00 per ounce; silver, if over 1 ounce per ton, 95% paid for at New York quotations. There was also a treatment charge of \$1.00-\$2.00 per ton f.o.b. smelter, if ore was neutral, with a charge of 4-5 cents per unit for excess of silica over iron, or a credit for excess of iron and lime over silica. A preliminary payment of 90% was made as soon as possible after sampling, at the prices ruling at date of arrival, and final payment was made 60 days later, at prices ruling on the fiftieth day after arrival.

SECTION III. VISIT TO NELSON.

1. *NELSON, 7th APRIL, 1915.*

The Commission visited the plant for the electric smelting of zinc ores which was constructed by Mr. F. T. Snyder about the year 1908. The plant has been used for a short time by the Dominion Government in 1913 for carrying out further experiments in electric smelting of zinc.

Mr. Thomas French, son of the inventor, gave the Commission an account of the "French" process for the production of zinc from its ores by electrolysis; details of this are given in Dr. Stansfield's report.

The Commission also met Mr. S. S. Fowler, of Riondel, B.C., general manager of the Blue Bell Zinc Mine, who gave important information on the zinc question.

The Commission visited the Nelson Iron Works of which Mr. Fowler is a Director and where Mr. Hinton, President of the Board of Trade, is Managing Director. Mr. Hinton gave the following particulars of the labour rates in Nelson.

	Rate per hour	Hours per day
Machinists	48⅓	9
Machine Helpers	37	9
Moulders	50	9
Labourers	35	9
Pattern Makers	50	8
Carpenters	50	8
Bricklayers	85-1.00	8
Labourers	35	8
Labourers, Sawmill	25-30	10

2. *ADDRESS TO THE PEOPLE OF NELSON, B.C., DELIVERED IN THE BOARD OF TRADE ROOMS, FRIDAY EVENING, APRIL 17, 1914, BY W. R. INGALLS.**

About a fortnight ago, just before I started for Nelson to make an examination of the work that has been done and is being done at the zinc plant here, I was in consultation with the Deputy Minister of Mines and the Director of Mines and I was authorized by them to communicate fully to you, the people of Nelson and the surrounding mining districts, my opinion respecting the work that we have had in hand, the advisability of future procedure and conditions generally. I have been associated with the present zinc investigation from the beginning, have advised the Department of Mines regarding it, have directed it generally and have been in close touch with it throughout, but less since we have been at Nelson, owing to the great distance. In talking to you about it this evening, I shall be brief, *i.e.*, I shall not take up your time in telling you about the problem of treating zincky ores in general, but shall confine myself to the points that are directly of interest to you.

The problem of treating mixed ores containing more or less zinc has been one of the most baffling of metallurgical problems during 60 years or more, and it is a problem that has remained without general solution. Much progress has been made in mechanical separation and in simple zinc smelting, which has rendered payable many ores that only 10 years ago were not so, but there remain many kinds of zincky ores which are still unprofitable, either because of their remoteness from market, or adverse conditions of production, or complex character or low grade, and unfortunately they are the kinds which are possessed by many mine owners, yourselves included. With regard to them the problem is not just how can they be treated, but how can they be treated profitably, which means the introduction of some process cheaper than anything the world knows today.

When the Department of Mines took up the investigation to find such a process, we did not enter upon it with the idea of

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*Published through the courtesy of Dr. Eugene Haanel, Director Mines Branch, Department of Mines, Ottawa.

thinking of electric smelting and nothing else, but we first reviewed all the recent work in the general field that we could learn of, and besides making our own studies we considered the processes that were offered by many inventors. We were unable to find anything that gave even reasonable promise. Without abandoning consideration of anything else, we then turned our attention to electric smelting, a subject of unknown possibilities, but attractive just because it was unknown. If you are going prospecting you don't go to the old diggings that have been searched for years, but you like to go to a new country where the surface indications are good. Now, the surface indications of electric smelting looked good.

We were aware, of course, that electric smelting had actually been practised in Sweden and Norway for a number of years, but we were also aware that it had not been either metallurgically or commercially successful. If you will refer to the Report on the Zinc Resources of British Columbia published by the Department of Mines eight years ago, a report with which I had something to do, you will find reference to that. We were aware also that electric zinc smelting was the subject of experiment by many other persons, both in Europe and America, but that none had been successful up to that time. It was therefore a fair field for study.

About two years ago a summary of a report upon the electric smelting in Sweden and Norway was published in the engineering papers and I was asked through the Department of Mines why the Scandinavian process could not be transplanted to British Columbia without any more ado. Having in my hands the full text of the documents mentioned with all their figures, I reported that British Columbia costs for electric power, labour, and other things were $2\frac{1}{2}$ to 3 times the costs in Sweden and Norway and that under these conditions smelting in British Columbia would be out of the question.

Since then the production of electric spelter in Scandinavia has attained considerable proportions, amounting now to some thousands of tons per annum. This is partly obtained from the smelting of zinc dross and zinc junk generally, but some of it comes from the smelting of ore. However, I may mention as a recent substantiation of my opinion regarding the introduction of this process in British Columbia, that the directors of the principal Scandinavian company reported officially last

November that up to last August they had not been able to smelt at a profit but were hopeful that improvements then being made would enable them to do so.

What then is the matter with the Scandinavian process? Primarily, it requires too much power, and among the reasons for the extravagant use of power is the inability to condense a sufficiently high proportion of the zinc directly as spelter. The blue powder is chiefly zinc, but it is zinc in a non-commercial form and in order to get zinc from it a resmelting is necessary, but that resmelting adds greatly to the cost of treating a ton of ore. This blue powder difficulty is one that has bothered every one of the score, or two-score, investigators of electric zinc smelting, save perhaps one who failed for other reasons.

We set out to learn how the condensation of zinc as blue powder could be reduced, and how the need for electric power could be otherwise cut down. We have no idea that blue powder could be wholly avoided, inasmuch as it is produced to a considerable extent in the ordinary process of fire smelting and we could not hope to do better than that. Theory indicated that we might attain the results of ordinary fire smelting in that respect and also that the requirement of electric energy might be otherwise reduced, and possibly enough to render power consumption no great stumbling block. That hurdle leaped there were the chances of smelting in a unit of relatively large size with possible economy of labour, and some other things as compared with ordinary fire smelting, and also it was possible that silver-lead, copper matte and spelter could be produced by one furnace in a single operation, and that a higher extraction of the zinc and especially of the silver and lead could be made than in ordinary smelting. Moreover, that some kinds of ore at present impossible of treatment, and there are such kinds, would be amenable to electric smelting. I say that these were possibilities. They were sufficient justification for spending time and money in testing them.

However, they were never in my mind anything but possibilities and I have never held out hope that they would be realized. On the contrary, I have been distinctly skeptical and guarded in what I have said publicly about the result. I have been confident that metallurgic success would be attained, and herein I distinguish between metallurgic and commercial,

although of course broadly speaking a metallurgic success is not a success unless it also be commercial.

In our work in the laboratory in Montreal, where we tested our theory, experimented with types of furnaces and learned the ABC of the art, we succeeded in assuring ourselves that the production of blue powder could be reduced to something like the proportions of ordinary smelting and had some hopeful indications of reduced power consumption. Then we came to Nelson to try things on a larger scale. When in the laboratory we graduated from a 20-lb. furnace to a 200-lb. furnace we encountered a new line of practical troubles. When we came here and graduated to a 2,000-lb. furnace again we encountered new troubles, but magnified.

As I observed operations from day to day I experienced the whole gamut of emotions. Some days, when things are going well, I am inwardly carried away with visions of what may be accomplished. Another day I am more chastened in spirit. The fact is that electric zinc smelting is a process of extraordinary delicacy. I know of nothing else in metallurgy that is comparable in its requirements to this one. In most processes, if things be set right they stay right with ordinary attention, but in this process there are at least eight different controls, all closely correlated and more or less interdependent, which may change from hour to hour, or even more quickly, and make things go bad. The ordinary process of zinc smelting is a process of delicacy, but electric smelting is far more so, any way as we know it yet. A friend of mine, himself an experienced zinc smelter, can see no future for electric smelting for this reason alone. I am far from being so pessimistic as that, but I will say to you positively that I cannot see any commercial possibility in a one-ton electric zinc furnace, or a battery of such, and when I think of a ten-ton furnace I am appalled. Just as we have experienced new and magnified troubles in going from a 20-lb. furnace to a 200-lb. and from a 200-lb. to a 2,000-lb., so we shall in going from a 2,000-lb. to a 20,000-lb. Indeed, the lines and working of a 20,000-lb. furnace are quite beyond my present conception, as they are beyond the conception of the staff here, I am sure.

We have not yet got our furnace here running to our satisfaction. We seem now to be able to keep it going and we make some spelter and matte and lead. If the work is continued I think it probable that before long the control of the variables would

be learned and a metallurgic success be pronounced. At the meeting of the Canadian Mining Institute about six weeks ago, Mr. W. McA. Johnson, who has been working upon electric zinc smelting for ten years, presented a paper describing a run with a one-ton furnace at Hartford, which was a metallurgic success to a considerable degree. I saw this furnace in operation during that run and at the time of my visit it was working smoothly and encouragingly. Mr. Johnson deserves very great credit for what he has accomplished. We have been working on similar lines, but he is a lap or two ahead of us. He has now organized a company, which is going to erect a ten-ton furnace at some place in the United States and test the thing commercially. He expresses himself confidently about it. Our own experience has led me to be much less sanguine, as you will have gathered from my previous remarks.

As you know, the appropriation that we have had is nearly exhausted. If work here is to be continued, more money must be forthcoming. I am speaking to you this evening merely as the consulting engineer, telling you squarely just what is the situation from the technical standpoint and expressing very frankly to you what are my opinions, for which I have been duly authorized by the Deputy Minister and the Director. I can not of course speak for the Government. It is my understanding that additional money was promised if necessary and that that is recognized in Ottawa. It is my duty only to advise, and I can not advise a Government any less honestly than I could a private client. I think that in due course of time the work now going on here would, if continued, be brought to reasonable metallurgic success. I am positive that even so there would be no commercial success to be expected from a one-ton unit or an extension of one-ton units. What it would cost to go on with the development of an eight-ton or a ten-ton unit is beyond human capacity of estimating. People who promote such pioneering developments usually do so with the idea that when the first funds are gone they will manage to get some more. In this case, although I will not venture any estimate, or even a guess, I foresee that a great deal of money would ultimately be required. Now it may be that an additional and large expenditure may be worth while, but we see another party who is further ahead than we are just about to do that thing; and I can say from my own knowledge, that its intentions are serious and that its financing, if not adequate,

is at least considerable; and in view of the great uncertainty of the outcome any way, I am of the opinion that it is wisest to await that outcome, which will not be long delayed, and then let it be decided whether any more money ought to be spent on similar work here. You will not be any worse off, save in a little loss of time and perhaps not even in that, and you may save a good deal of money. This is my advice to the Department and to you.

W. R. INGALLS.

SECTION IV. VISIT TO VICTORIA.

A DISCUSSION IN RELATION TO THE REFINING OF COPPER AND ZINC IN CANADA.

Empress Hotel, Victoria, B.C.,
Monday, 12th April, 1915.
11.00 a.m. to 1.00 p.m.

PRESENT:—

COL. D. CARNEGIE, London, England.
DR. A. W. G. WILSON, Mines Branch, Ottawa.
W. F. ROBERTSON, ESQ., Provincial Mineralogist.
DR. A. STANSFIELD, McGill University, Montreal.
F. ELWORTHY, ESQ., Sec. Board of Trade, Victoria.
A. C. FLUMERFELT, ESQ., Victoria.
C. H. LUGRIN, ESQ., Victoria.
COL. E. G. PRIOR, Victoria.
W. BLACKMORE, ESQ., Victoria.
A. G. BURDICK, ESQ., Victoria.
W. BLAKEMORE, ESQ., in the chair.

The discussion was opened by Colonel Carnegie who explained the reasons which led to the present inquiry into the possibility of refining copper and zinc in Canada. He referred to some questions which would be submitted to the Victoria Board of Trade and which are given separately with their answers. He explained that the refining of copper would incidentally act as a stimulus to industries using copper which would naturally be established in the neighborhood.

Dr. Wilson and Mr. Robertson gave figures with regard to the imports of copper into Canada, which are contained in Dr. Wilson's report. It was shown that Canada exported twice as much copper (in the form of ore, etc.) as it consumed and that British Columbia alone produced as much copper as was consumed in Canada. There was, however, in addition, some 3,000 tons of copper—in the form of brass, which had not been included in the consumption already referred to.

Mr. Flumerfelt explained that when he was interested in the Granby Company they considered the installation of a

refinery and compared three locations—namely, the St. Lawrence, Port Arthur and the Pacific Coast. Their decision was in favour of the last named point on account of the water transportation and the probability of a large supply of copper within easy reach; also the fuel is easily obtained and large amounts of hydro-electric power are available. He mentioned that mines in Montana, Oregon and Washington are shipping to New York and New Jersey and said that in view of this the shorter transportation obtained by selecting a point on the Pacific coast was very desirable.* The difficulty at that time was to obtain a sufficient amount of ore to operate a smelter which would necessarily form part of a refinery. They wished to obtain the output of the Britannia Mine, but were unable to arrange for this. At present the difficulties have been partially solved, as the Granby Company have erected at the Observatory Inlet a plant costing $3,500,000.

Mr. Robertson pointed out that the cost was $8,000,000 to $10,000,000 and that the ores would yield more than 40 lbs. of copper per ton.

Mr. Flumerfelt referred to the large supplies of ore in the southern country and around Phoenix, including that of the British Columbia Copper Company, which he supposed would come to a refinery established at the coast.

Mr. Robertson said that the Tyee Company intended to start a refinery, but that they were unable to do so for fear of unfriendly action by the owners of the Tacoma smelter who would have prevented them from obtaining supplies. The Guggenheims are supposed to own or control this smelter. The question was raised whether that opposition would not still operate to prevent a refinery being established at the coast. The opinion was expressed that if copper could be refined there more cheaply than by shipping it to the east the Guggenheims would not oppose it but would support it if it were in their financial interests to do so.

Mr. Robertson said that it was cheaper to transport copper to New York in the state of blister than in the state of refined copper, so that if New York were the final market there would be no advantage in refining the copper at the coast.

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*The meaning of this remark is not quite clear. The stenographer may not have transcribed it correctly.

Mr. Flumerfelt said that the only objection to the coast for a refinery was the high price of labour. In regard to markets, some copper could be employed locally, and refined copper could be shipped directly from Vancouver to Europe. It was pointed out that the production in Canada was only 2% of the world's production and that this was very small in proportion with the American production. The question was raised whether the Americans would cut the price of copper in order to ruin a refinery in Canada. Mr. Flumerfelt considered that he would not mind taking the risk.

The use of aluminium instead of copper for transmission lines was discussed. The Chairman stated that the United States Government might discriminate against refining of copper in Canada in order to keep that industry within their own borders, but Mr. Carnegie stated that refining should be done in Canada in spite of anything that might be attempted in that direction.

Dr. Wilson enquired what would be the attitude of the western copper producers in Canada that are not Canadian owned; the larger companies, with the exception of Trail being owned in the United States.

Mr. Robertson said that they were controlled in the United States, but that a large proportion of the stock was held in Germany, and Mr. Flumerfelt said that the Germans nearly controlled the metal market of the United States. It was brought out that some of the American zinc smelters refused to supply zinc when required for export to Great Britain.

The possibility of refining nickel and its associated copper in Canada was referred to and the action of the Canadian Government in not putting an embargo on the export of nickel was explained. The Chairman mentioned that a small copper refinery would probably be established at the Trail smelter. The ownership of the Granby Mine was discussed, and it was stated that while theoretically a Canadian Company, the head office is really in New York, and there are probably 2,500 shareholders. Mr. Flumerfelt said that he thought the Guggenheims had no interest in the Britannia undertakings, but Mr. Robertson considered that the Guggenheims might have made some advances in connection with recent construction and that the ore from the Britannia Mine might all go to the United States.

Dr. Stansfield raised the question of the possibility of smelting zinc in Canada and explained the difficulties in regard

to the low grade of the available ore and the possibility of using an electrolytic process. Mr. Robertson agreed with these conclusions saying that the ore was not suitable for the Belgian process with the exception of that from a couple of mines—the "U.S." and the "Lucky Jim."

2. *REPORT ON COPPER AND ZINC REFINING IN CANADA SUBMITTED BY THE MINING COMMITTEE OF THE BOARD OF TRADE VICTORIA, B.C.*

GENERAL.

1\. Q. What in your opinion are the prospects for the establishment of a copper refinery in British Columbia that would be a commercial success?

A. In the opinion of this Committee the prospects are excellent, based upon the following considerations:—

(*a*) The production of copper ore in British Columbia is about 4,000,000 lbs. per month, and is steadily increasing. Such well known companies as the Granby, producing at Grand Forks, 1,000,000 lbs of copper matte per month and a similar amount at Anyox, and the Britannia Mines producing also 1,000,000 lbs. per month furnish about three times as much as is required for one refinery. These companies are all financially sound and progressive, and contemplate increased production. There are many other properties which need not be summarized, producing smaller tonnages.

(*b*) Transportation facilities at the coast are excellent, surpassing those of the interior of British Columbia, and of any other part of Canada contiguous to copper mines. In addition to the exceptional facilities of water transportation so greatly enhanced by the opening of

the Panama Canal to traffic,* there are three Canadian Trans-continental railways: The Canadian Pacific, The Canadian Northern and the Grand Trunk Pacific, with their termini at the coast. In addition there are three American Trans-continental roads running into Seattle, which is only seventy miles south of Vancouver.

(*c*) There are a number of water powers, both on Vancouver Island and on the mainland near the coast, which will yield an abundance of cheap power for smelting purposes. In the opinion of experienced engineers this power can be generated for $10.00 per h.p. per annum, and possibly for $7.50.

(*d*) Water transportation furnished at the coast would not only be an important factor in the shipping of refined copper, but would stimulate secondary industries in which copper and brass are used by bringing them in easy touch with the principal export markets.

(*e*) There is on Vancouver Island an unlimited supply of good bituminous coal, which is at the present time yielding a smelting coke. This coal is high in by-products, and if treated in by-product ovens instead of in the wasteful bee-hive would become a profitable adjunct of the smelting and refining industry, and ultimately when the by-products can be marketed, would supply fuel coke at a nominal price.

2. Q. What location or locations would in your opinion be the most advantageous, and why?

A. This question is answered by the foregoing:—The main advantage of the coast as against any point in the interior is, that of water transportation and the probability that the larger and more permanent tonnages of copper ore will be produced at or near the coast. The

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*The canal has been closed by a landslide at the Culebra cut since November, 1915.

bodies of known ore are immeasurably larger, and the prospects for favorable development greater.

3. Q. What are the comparative costs in Canada and the United States for:—
   (*a*) Labour?
   (*b*) Power?
   (*c*) Fuel?
   (*d*) Cost of living?

A. Generally speaking it may be said that the cost of labour and of living is about the same in British Columbia as in the Western States of Washington and Oregon, but compared with the Eastern and Middle States, both items are approximately one-third higher at the coast. With respect to power:—This Committee has no data on Eastern prices but as stated in answer to question one, clause "c", it can be generated at the coast at $7.50 to $10.00 per h.p. per annum. With respect to fuel:—This is much higher than in the Eastern States, but approximately the same as in Washington. It must, however, be borne in mind that British Columbia coal is of a higher grade than the American Western product, and finds a readier market. The prevailing rate for run of mine coal is $4.00 per ton. There is, however, no reason why the treatment of British Columbia coal in by-product ovens should not entirely wipe away the margin between Eastern and Western fuel.

4. Q. What production of blister copper per annum would be needed to support a copper refinery on a commercial basis?

A. The minimum economic unit may be set at 30,000 lbs. a day. This would depend to some extent upon the system adopted, and appendix "A" gives details of respective costs of the two best systems, the "Multiple" and the "Series." From the appendix it will be seen that the cost of such a unit would be approximately $81,542.00 based on Eastern prices. It is probable that under existing conditions it would cost $120,000 in the West.

5. Q. What quantity of zinc ore is necessary to ensure the successful operation of a zinc smelter?

A. In view of the fact that the subject of zinc smelting is under investigation by the Dominion Government, and that no decision has yet been arrived at as to the best system; also having regard to the fact that while there are known to be large bodies of zinc ore in British Columbia, the metal has not yet been produced except as a by-product of lead, the Committee suggests that it is premature to attempt any reply to the question relating to zinc smelting.

MINING

Copper Mining.—

1. Q. What prospect is there of the copper production on the coast being increased?

A. An excellent prospect due to the fact that the two large producing mines that of the Granby Company at Anyox and the Britannia Mines are in the hands of strong financial companies, and are constantly increasing their production. They have in a short time overtaken the yield of the older Granby Mines at Phoenix, and contemplate a very much larger production. It has been officially announced by the directorate of the Britannia Mines that their objective is double their present output of 1,000,000 lbs. of copper matte per month. As the mines at Anyox have already proved more than 20,000,000 tons of ore, there is no reason to suppose that the management will be satisfied with a smaller tonnage than Britannia.

2. Q. What properties now undergoing development give promise of adding to the coast production, apart from increases which may be expected from the mines now being operated?

A. So far as your Committee is aware there are no properties now undergoing development at the coast, other than those referred to, but there are a number of excellent copper prospects on which a small amount of preliminary work has been done, and which give excellent promise of becoming mines.

Zinc Mining.—

3. What zinc prospects are known on the coast?
4. Have they ever produced ore, and how much?
5. Have you accurate information as to the tonnage available?

A. The Committee is leaving these questions unanswered for reasons explained in a previous paragraph of this report.

POWER.

1. Q. At what points on the coast is electric power now available?

A. Victoria and Vancouver and surrounding districts.

2. Q. Is it being utilized at all?

A. Yes, extensively.

3. Q. What capacity is lying idle?

A. Practically unlimited.

4. Q. Where could the cheapest electric power be obtained?

A. Probably by the development for smelting and refining purposes of one of the undeveloped powers. There are several convenient.

5. Q. What would be the lowest cost per h.p. year or per kilowatt hour?

A. $7.50 to $10.00. .

6. Q. How much would be obtainable?

A. Practically unlimited.

FUEL.

Coal.—

1. Q. What is the cost of coal at the pit mouth?

A. The actual cost varies in the different coal districts of British Columbia, but a fair average for Vancouver Island coal would be $2.50 per ton f.o.b.

2. Q. Have you any data on the actual cost of production?

A. Yes but they were given in confidence and are not available for publication. The net result is as above.

3. Q. What does coal cost at Ladysmith?

A. To produce, $2.50 a ton. Sale price, $4.00.

4. Q. Are the Vancouver Island coals good coking coals?

A. All the Vancouver Island coals will coke, and the Comox coals make a good commercial coke, which has found a considerable market for smelting purposes. There are other coals on the main land not far from the coast, which are richer in by-products, if by-product coking were developed at the coast it would probably pay to freight these interior coals and so obtain a higher grade of coke at a reduced cost, but this statement is not intended to weaken the claim that Vancouver Island coals would answer all the purposes of smelting fuel.

Oil Fuel.—

1. Q. What does crude oil and what does fuel oil cost on the coast?

A. 80 cents a barrel for large contracts.

2. Q. What are the sources of supply?

A. California.

3. Q. What is the equivalent quantity of each, crude oil and fuel oil, in comparison with one ton of coal from Nanaimo or Wellington Colleries?

A. $3\frac{1}{2}$ barrels.

LABOUR.

1. Q. What are existing labour conditions on the coast? Union? Open-shop? In what trades?

A. Almost entirely Union. There is practically no open shop.

2. Q. What is the prevailing scale of wages for skilled and unskilled labour in the various trades?

A. Mechanics, 50c. hr.; carpenter \$4.25; bricklayer \$5.00; engineer \$4.00; unskilled \$3.00; all per 8 hr. day.

NOTE:—These rates prevailed before the war. Unskilled labour is now lower.

FREIGHT.

1. Q. What are the existing rates on copper and zinc ores and on blister copper from:—

(*a*) East Kootenay to Vancouver?
(*b*) Boundary to Vancouver?
(*c*) Boundary to New Jersey or Montreal?
(*d*) Coast to coast (by rail)?
(*e*) Coast to coast (by Panama)?
(*f*) West coast to European market?

A. The transportation companies are unable to give rates at this end and suggest that application be made to the head offices of the transportation companies in Montreal.

MARKETS AND MARKETING.

1\. Q. Where would refined copper from British Columbia be marketed?

A. There are two natural markets. The home market and England. Of the total production of copper matte, amounting to 37,500 tons, the whole of which is now exported to the States for refining. 21,000 tons is re-imported into Canada as copper, in addition to 3,000 tons brass. The home market is growing, and will probably consume increased quantities each year. The balance of the copper, if refined in Canada, would be exported to England.

2\. Q. Where would refined zinc from British Columbia be marketed?

A. See previous remarks on zinc.

3\. Q. What would be the influence on other Canadian industries if a copper refinery were established on the coast?

A. In the opinion of this Committee the influence would be very great and beneficial, for the following reasons:–

(*a*) It would stimulate the development of copper mines, and so increase the demand for labour and supplies.

(*b*) It would place our total supplies of refined copper at the disposal of the empire, and enable Canada to retain control.

(*c*) It would stimulate the creation of secondary industries in which copper plays an important part.

(*d*) It would have an indirect but important influence on the development of other industries, and especially on an industry which is of more vital importance to the coast than any other, viz:—the smelting of iron ores and the manufacture of iron and steel. Its direct bearing upon this important subject would be that copper refining would lead to the utilizing of our great water powers, which would thus become available for other purposes also, and would certainly lead to the coking of coal in by-product ovens, and the production of cheaper coke. Viewed in this light the smelting industry whether of iron or copper ores may be regarded as one. Anything which ensures by-product coking, the distillation of coal, and the production of fuel gas from raw coal would be a boon to every industry at the coast, and would have a direct and potent influence on its development. In this connection the Committee offers in Appendix two, a memorandum on by-product coking, and in Appendix three, a memorandum on coal dust and its use in regard to smelting copper ores.

4\. Q. How will the United States copper refineries view the establishment of a refinery in Canada?

A. This is of course a matter of conjecture, but the experience of Canada with the United States would lead us to expect the strongest opposition to such a policy. That opposition could only take the form of underselling in such market as Canada would be able to reach so as to make the trade unprofitable. As the Canadian production is only about two per cent. of the world production this would be an easy matter and a consideration of the subject in this aspect suggests that the industry would have to be protected or assisted in a special manner. The Committee takes it for granted that this would present no difficulty if copper refining is viewed in the light of national and imperial policy.

There is another phase of this question to be considered, viz:—the attitude of the copper mining companies now operating in British Columbia. Practically all these companies are American, that is the capital is held in the United States. Further, they are German-American and it is conceivable that under certain circumstances they might endeavor either to prevent Canada reaping the benefit of a local refinery, or restricting the output of copper ore in order to reduce the supply of copper. It does not seem to this Committee that there should be any difficulty in dealing with such a situation if it were created. British Columbia has been able to legislate against the exportation of logs, and if the cases are not exactly parallel there does not seem to be any reason why a similar policy could not be adopted with copper. All that this Committee feels called upon to do is to suggest the probability of an unfriendly attitude on the part of the copper mining companies as a factor.

A. C. BURDICK.
HENRY B. THOMSON.
W. BLAKEMORE, Chairman.

APPENDIX No. 1.

THE ELECTROLYTIC REFINING OF BLISTER COPPER 98% Cu.

The smallest economic unit for a copper refinery is one with a daily capacity of 30,000 lbs., which is approximately equal to 10,000,000 lbs. per annum.

THE COST PER TON OF CATHODE COPPER PRODUCED IN A PLANT OF THIS CAPACITY WOULD BE AT EASTERN RATES.

Making anodes (including re-working slag)	$ 3.40
Fuel at $4.00 per ton (in Electrolysis)	3.66
Consumption of energy in conductors	.26
Expense involved by loss of efficiency	.18
Treating slimes	.90
Labour (including superintendance)	3.68
Interest on $82,000.00 at 5%	.74
Interest on stock of Copper in process	1.41
Maintenance of plant	.76
Oil, waste, light, etc.	.17
Total for refining, exclusive of insurance and office expenses	$15.16

APPENDIX No. 2.

COST OF A COPPER REFINERY, OUTPUT 30,000 lbs. DAILY AT EASTERN RATES.

Building, area 25,450 sq. ft., 500,000 ft. lumber, $9.00	$ 4,500.00
Framing, 50,000 ft., includes windows, nails, pins, spikes, $16.00	8,000.00
1 Reverberatory furnace (10 ft. x 16 ft. hearth) with anode moulds	4,000.00
1 Reverberatory furnace (10 ft. x 16 ft. hearth) with water bosh and ingot and wire bar moulds	4,500.00
1 36-inch water jacket blast furnace for reducing slag, complete with electric motor, fan blower and 12 slag pots	1,200.00
Excavation for boiler, engine and dynamo foundation	300.00
Foundations, include stone, cement and mason work	1,600.00
5 72-inch by 16 ft. R. S. boilers, including brickwork at $16.00 per horse power	8,000.00
Air pumps and jet condensers	1,390.00
2 300-h.p. compound condensing Corliss Engines at $13.00 per h.p.	7,800.00
2 180-k.w. direct current shunt wound generators at $23.00 per k.w.	8,280.00
Asphalt for flooring at 75c a yard	525.00
Circulating apparatus and air pump	400.00
Receiving tanks, reservoirs and launders	245.00

3,500 ft. 1-inch pipe, 100 1-inch tees, 100 1-inch faucets	220.00
300 lead lined tanks, with stringers and brick pieces at $30.00	9,000.00
Overhead track	600.00
Silver Refinery	3,500.00
Rectangular conductors, 58,350 pounds at 14c	8,169.00
Round conductors, 11,566 pounds at 13c	1,504.00
Rolled plates for cathodes 3,060 sq. ft., 7/32 inches thick, 31,212 pounds at 13c	4,057.00
Contingencies	5,000.00
Total Cost	$ 81,542.00

APPENDIX No. 3.

BY-PRODUCT COKING IN ITS RELATION TO SMELTING.

The recovery of benzol has received much attention of late, owing to the fact that a large quantity of refined benzol is now used in place of petrol as fuel for motor engines.

The majority of coke ovens and plants now have benzol recovery plants, but very few produce refined spirit; what is known as "crude or 65%" benzol being generally made. The benzol can be extracted from the gas without affecting the amount of energy obtained from it when used for boiler firing purposes, or for combustion in gas engines by more than about 5 to 10%.

The quantity of benzol obtainable differs according to the nature of the coal. The recovery of benzol from coke oven gas is now universally effected by means of absorption in creosote oil—a product obtained in the distillation of coal tar—and the difference between the various systems on the market lies principally in the internal arrangement of the apparatus employed, and the temperature and steam pressure at which the various parts are worked.

Coke Oven Gas is now very largely used as a fuel in iron and steel works, and has been used in open hearth furnaces with great success, in some instances practically replacing the whole of the coal formerly used.

The Dominion Iron and Steel Company, Limited of Canada, claims that the surplus gas from the coke ovens of the company is used entirely in the steel department,* one hundred tons of lime per day for use in basic Bessemer and open hearth furnaces is burnt (1914), and the mixer into which all the iron from the blast furnaces is put before going to the steel plant is certainly heated by coke oven gas.

The dolomite for open hearth and Bessemer work is calcined by coke oven gas, and all ladle drying is done by the same means.

Coke oven gas is also used to a certain extent for re-heating ingots before rolling, but this is not constant practice. Any surplus gas not required for the

*Benzol and Toluolane now extracted from the waste gases and is used for the manufacture o Trinitroluol.

above purposes is used in the open hearth furnaces for steel melting. The calorific value of the gas is about 525 B.T.Us per cu. ft. benzol not being extracted.

There is no question but that the greatest economy possible in steel works practice is through the general adoption of by-product coke ovens, and not the least of these is in the proper utilization of the large quantities of surplus gas.

The Dominion Coal Company estimate the saving effected by the use of the by-product oven to be $1.93 per ton of coke made.

ESTIMATE FOR BY-PRODUCT PLANT, KOPPER'S OVENS.

Assume plant will make 425,000 tons of coke per year.

425,000 tons of coke, 1,700,000,000 cu. ft. of gas per year at 10c per 1,000 cu. ft., value	$170,000.00
Ammonia sulphate at 15 lbs. per ton of coke; 3187 tons at $60.00 per ton	191,220.00
Tar at 2c a gallon, 7 gallons per ton	59,500.00
Total value of gas, ammonia and tar	420,720.00

These are conservative figures, or roughly 10% interest on a capital investment of $4,000,000 saved in these by-products alone, not counting coke sales and other products.

The cost of a plant complete for 80 ovens, $1,100,000 to supply 425,000 tons of coke.

Bee-hive oven plant we would get 60% coke.

By-product plant we would get 80% coke.

Modern by-product plants have a capacity of as much as 20 tons of coal per oven per day.

By-product coke is the best on the market.

By-products from coke ovens in 1914 for Canada:—8,572 tons of ammonia sulphate, 5,714,172 gallons of tar and 3,201,097 thousand feet of gas.

ECONOMY.—From 80 to 130 cu. ft. of gas are required to develop 1 H.P. per hour when the gas is burned under a boiler, and the steam produced is used for driving a steam engine of the ordinary type.

The same power can be developed with a consumption of 9 to 15 cu.ft. per hour in a gas engine of equal reliability and the same cost of maintenance. Hence a great saving can be effected if the gas is employed directly in a gas engine.

Average price of natural gas in Canada, 15c per 1,000 cu. ft.

3. *A. C. FLUMERFELT, ESQ.*

Victoria, 15th April, 1915.

To COL. D. CARNEGIE,
Chairman of the Copper and Zinc Commission, Ottawa.

Dear Col. Carnegie:—You desired me to give you, in writing, some of the ideas expressed when I had the pleasure of discussing the question of the erection of a refinery in Canada.

When I was an active officer of the Granby Consolidated the question of refining our own metals was carefully considered, and after very exhaustive examination and mature deliberation the management was authorized to make a selection of a site for the proposed refinery, at or near Pacific tidewater.

There were three points considered. One was on the St. Lawrence, the second at or near Port Arthur, and the third on the Pacific coast. Recognizing that the successful establishment of such a large undertaking involved corresponding expenditure, we took into consideration three fundamentals:

Raw material,
Labour, and
Point of distribution.

Considering the St. Lawrence or any point in the East, the raw material would of necessity have to bear heavy transportation charges.

The labour condition would probably be better in one of the above mentioned points than on the Pacific coast.

As to distribution, it was felt that as the country develops the demand for such products as could be manufactured would be chiefly in the western provinces (export to the Orient was not then considered) and as Europe was the largest consumer of copper, an excess beyond what might reasonably be required for local consumption could be transported cheaply from British Columbia to European Markets—speaking now of copper going in raw ingots. Then, too, it was considered this would stimulate the smelting industry in the copper province of the Dominion, that is, British Columbia.

We decided upon a site on Burrard Inlet, about midway between Vancouver and Port Moody. This inlet, as you perhaps know will admit of practically an unlimited number of deep-sea

vessels going in and out at any time, as it is a very large expanse of water some fourteen miles long and can be approached at any state of tide. Then, too, such a site would be within easy touch of all transcontinental railways and within reach of the Northern Pacific and Great Northern railways on the American side.

Electrical power can be obtained cheaply either by purchase from one or other of existing companies, or by the development of adjacent streams; fuel is to be had in great abundance within eighty miles. The employees would have country life and at the same time enjoy the advantages of the largest commercial city in the west (I speak, of course, of the Canadian side), so that for the purchase of supplies, educational facilities and generally for the well-being and comfort of the employees such a situation is ideal.

As above intimated, we had already made out plans and would have gone on with the undertaking provided we could have been assured of a sufficient supply of ore to guarantee the continuous operation of a small smelter, which was a necessary adjunct and the forerunner of a refinery. This condition has now been overcome, and I am satisfied a bountiful supply of blister and matte could be arranged for, therefore, were I now directly associated with such an undertaking I should have no hesitation in carrying out our original idea. Under existing financial conditions it would be somewhat difficult to secure the erection of a refinery by private investors, but, as suggested, will outline what I think would be a feasible plan.

When the tonnage has been determined upon and the cost of a unit ascertained, assume that the Imperial Government were to provide the necessary capital for the construction and completion of this work, and a moderate sum for general operation. The organization to be on a stock company basis.

It would appear probable that a number of the large mines and smelters—and perhaps others—would become subscribers to the stock, particularly if payment could be made by way of percentages on the material from time to time supplied by these various organizations, spreading the total over a period of years. Then, too, one or more of the power companies could perhaps be induced to take a proportionate amount, based on a percentage of contract for power entered into by the refinery. It might also be possible to interest some of the railway companies.

Am satisfied the municipality would for a period of years grant freedom from taxation and free water.

Were such a plan possible of accomplishment, it would in my opinion insure permanent and continuous operation of such an undertaking, and as the country develops, all the different interest would be on the alert to increase and improve it. Doubtless the Dominion and Provincial governments would be in hearty sympathy with such an undertaking, recognizing—as all must do—the importance of controlling, as far as may be, the natural products of our country. It should also be borne in mind that the copper interests of British Columbia are largely controlled by foreigners, and at the moment both matte and blister are shipped to United States refineries.

Were these companies not in sympathy with such a plan as I have in mind, it would be within the province of the Dominion to legislate against export, either by way of levying an export duty or on the principle of rebating tax on all products manufactured in Canada.

I do not know that there is anything more I can add, but if I can be of assistance to you or the Government in working out this very important project, I shall be pleased to have you command me.

I have very pleasant recollections of your visit to British Columbia, and hope the time may not be far distant when that pleasure may be renewed.

Faithfully yours,

(Sgd.) A. C. FLUMERFELT.

4. *W. F. ROBERTSON, PROVINCIAL MINERALOGIST*

Victoria, B.C., 24th April, 1915.

Replies to questions asked by the Commission.

GENERAL.

1. Q. What in your opinion are the prospects for the establishment of a copper refinery in British Columbia, that could be a commercial success ?

A. The term "Copper Refinery" is hereinafter presumed to include an electrolytic depositing plant, as all our ores carry gold and silver values, and subsequent reverberatory refining furnace plant equipped for making standard sizes and shapes of refined copper. If not operated in conjunction with a copper ore smelting plant already in existence, a small unit of such would have to be provided. From a metallurgical standpoint, there is nothing to prevent the establishment of a copper refinery in British Columbia. From an operating standpoint:—Hydro-electric power costs about the same as in the East, but is more abundant here, and is cheaper than fuel generated electricity. Labour of the class required for such a plant would be at first more costly, but after the plant had been established a few years, to permit of training of local labour, would not be so prohibitory. Fuel of a class suitable for reverberatory furnace work is to be had on Vancouver Island at a price of about $4.00 a ton, and in Crows Nest Pass at about $2.25 a ton f.o.b. mines.

2. Q. What location, or locations would in your opinion be the most advantageous, and why?

A. A refinery can be much more economically operated if located at, and run in conjunction with an ore smelting plant, as refinery slags go back to the blast furnaces, etc., while overhead, general and laboratory expenses are eliminated, or at least divided. If not so located, additional capital expenditure would be required to provide a small unit. This and transportation facilities to market I consider the most important factors in

deciding location. The supply and price of fuel, fireclay, firebrick, lime, fresh water, are probably more favourable in British Columbia, than in Eastern Canada, while in British Columbia as regards the Boundary District or the general vicinity of Victoria and Vancouver—in these matters it would be almost a "stand-off."

3\. Q. What are comparative costs in Canada and the United States for:—

(*a*) Labour?
(*b*) Power?
(*c*) Fuel?
(*d*) Cost of living?

A. The comparative cost of labour, power, fuel and cost of living are about the same in the portions of Canada and the United States bordering on the Pacific coast, while both are somewhat higher than Atlantic seaboard.

4\. Q. What production of blister copper per annum would be needed to support a copper refinery on a commercial basis?

A. My personal experience would indicate that a copper refinery having an output of about 1,000,000 lbs. refined copper a month is the smallest unit that could be commercially operated and face competition.

5\. Q. What quantity of zinc ore is necessary to insure the successful operation of a zinc smelter?

A. I can not answer this from personal experience, but I have understood that a unit should be able to handle 50 tons ore daily.

6\. Q. What by-products would be available and what disposition could be made of them?

A. Sulphide zinc ores might be roasted to make "chamber acid" as a by-product.

MINING.

A. *Copper Mining.*—

1\. Q. What prospect is there of the copper production on the coast being increased?

A. There is every prospect of the copper production of

the coast district of British Columbia being very largely increased in the next few years. Properties now operating will probably double the output.

2. Q. What properties now undergoing development give promise of adding to the coast production, apart from increases which may be expected from the mines now being operated?

A. There are several properties which give substantial promise of production, but development has not proceeded far enough to permit of definite statements as to tonnage and assay content and they had consequently better not be named.

B. *Zinc Mining.*—

3. Q. What zinc prospects are known on the coast?

A. The "Lynn Creek" zinc properties near North Vancouver is the only zinc prospect on the coast of British Columbia that has been developed to any extent.

4. Q. Have they ever produced ore and how much?

A. The property has not as yet shipped ore and would require a concentrator before being able to do so.

5. Q. Have you accurate information as to the tonnage available?

A. A report on the property will be found on page 307 *et seq.* of British Columbia Minister of Mines Report for 1913.

FUEL.

A. *Coal.*—

1. Q. What is the cost of coal at the pit mouth?

A. Run of mine coal of quality suited for copper refining has been selling wholesale at about $4.00 a ton for Vancouver Island coal, f.o.b. vessel. Crows Nest coal at about $2.25 a ton, f.o.b. cars.

2. Q. Have you data on the actual cost of production?

A. Nothing officially known.

3. Q. What does coal cost at Ladysmith?

A. Answered in Q. 1.

4. Q. Are the Vancouver coals good coking coals?

A. Some of the coals are and other are not.

B. *Oil Fuel.*—

1. Q. What does crude oil and what does fuel oil cost on the coast?

   A. Contract prices not officially known—a high Canadian Pacific Railway official told me California crude oil, delivered in tank steamers cost them 80 cents a barrel.

2. Q. What are the sources of the supply?

   A. Up to the present time, California.

3. Q. What is the equivalent quantity of each, crude oil and fuel oil, in comparison with one ton of coal from Nanaimo or Wellington collieries?

   A. Engineers on coastwise steamers inform me that it takes from $3\frac{1}{2}$ to 4 barrels of California crude to do—on these steamers—the work of 1 ton of Vancouver Island coal that they formerly used. The Canadian Pacific Railway or Grand Trunk Pacific Railway could give exact figures.

MARKETS AND MARKETING.

1. Q. Where would refined copper from British Columbia be marketed?

   A. Assuming war conditions to have ceased and judging from past experience, it seems probable that for some years to come the great bulk of any copper that might be refined in British Columbia would find its way to the Atlantic, either by rail or water. Statistics show that both Canada and United States each produce over double the amount of copper they consume—they therefore have to export the surplus—so that we cannot look to United States for a market. South America is a large exporter of copper. The Orient is credited with a copper production of double its consumption. There is, therefore, only Europe left as an export market, in which Germany has been the greatest consumer, followed by Great Britain and France. The Canadian copper consumption takes place chiefly in Ontario and Quebec, the western consumption has not as yet become important.

2\. Q. Where would refined zinc from British Columbia be marketed?

A. Cannot venture even a guess as to export market. The domestic consumption would for some years at least be east of Winnipeg.

3\. Q. What would be the influence on other Canadian industries if a copper or a zinc refinery were established on the coast?

A. The prices of copper and zinc are settled in the world's market, and either a copper or zinc refinery on the coast of British Columbia would not materially effect these prices, local advantages from freight charges would occur in varying degrees. The greatest advantage would be in securing a supply of metal in a usable state, free from any possible foreign interference.

4\. Q. How will the United States copper refineries view the establishment of a refinery in Canada?

A. It is probable they would resent it— the copper refiners of the eastern states control the world's copper market and through the mines they control and regulate the production so as to maintain prices, and they are jealous of anything which would tend to weaken this control; they do not object to anyone making matte or blister copper, as long as it is not refined to usable state. As an example, the Guggenheims bought the Tacoma Smelter only after it had established a copper refinery, and promptly shut down the refinery; they did not need the smelter. The form of retaliation a British Columbia copper refinery would be subjected to would probably be—an underbidding of such refiner for the supply of crude copper or ores if they could not control it through stock in the producing mine. Hence the advisability of a refinery being built by a company controlling a copper supply from its own mines. It is, of course, possible that any such outside interference might be overcome by a Government bounty on refined copper or export duty, which might be justified by the shaking off of the economic dependency we are under today.

SECTION V. VISIT TO VANCOUVER.

Extracts from Minutes of meeting of the Mining Committee of the Board, held in the Council Chamber of the Board of Trade Rooms, on Tuesday, April 13th, at 11.00 a.m.

Present:

N. Thompson, Convenor, E. A. Haggen,
Jonathan Rogers, President, A. E. Hepburn,
G. E. Graham, Vice-Presdent, H. G. Ross,
W. A. Blair, Secretary.

There were present also, Mr. David Carnegie, the representative of the Shell Committee in Canada, Dr. Alfred W. G. Wilson of the Dominion Mining Department, Dr. Alfred Stansfield of McGill University, all of whom had been appointed by the Federal Government as a commission respecting the supplies of copper and zinc.

There were also in attendance, at the invitation of the Committee, Messrs. R. Hedley, E. A. Emmens, J. Gould, and McLeod.

Colonel Carnegie explained the scope of his Commission and asked for the opinion of those present with regard to the possibility of refining copper and smelting zinc in British Columbia. He supplied a number of questions which, with their answers, are given elsewhere.

Mr. Thompson stated that a commercial refinery would require from 75,000,000 to 100,000,000 lbs of copper per annum, but that at present only about 50,000,000 lbs. of copper was produced in British Columbia per annum. Dr. Wilson stated, however, that there was insufficient smelting capacity at the present time to supply the necessary amount of copper for a refinery. The possibility of the United States producers cutting prices in order to injure an infant refinery in Canada was discussed; Col. Carnegie explaining that the United States produced about 56% of the world's supply of copper while Canada only produced about 2%. Mr Hedley considered that in view of these figures the United States operators would not be inclined to try to crush

a small Canadian Industry. Mr. Thompson shared this view. Col. Carnegie stated that it was desirable to have the profits which could be produced by refining Canadian copper kept in Canada. Mr. Hedley considered that providing sufficient copper could be secured, a refinery on the coast would be successful, and in a few years would secure trade in England and India, but that sufficient copper could not be obtained in competition with the Granby Company and the Consolidated Mining and Smelting Company. He said that the market for copper in the future would be the Orient, the West Indies, South America and Europe and that with the aid of the Panama Canal all these points could be economically reached.

Mr. McLeod spoke of three or four properties in British Columbia containing silver, lead and zinc which would shortly be opened up if they could arrange for a satisfactory treatment which would save the three metals.

Mr. Rogers considered it very desirable that the copper industry should be developed from a national stand-point using Canadian or British capital.

Mr. Emmens spoke of some zinc properties in north Vancouver which were as yet only prospects.

Mr. Haggen stated that as soon as the output of the Granby Co. reached 100,000,000 lbs. per year they intended to put in a refinery on their own account. Mr. Thompson considered that the best locality for a refinery would be between Cumberland and Nanaimo or between Powell River and Vancouver. The Granby Co. procured their coke from the Crows Nest and it costs them $10.00 per ton. Their output of copper when the present smelter is completed was expected to be 50,000,000 lbs. per year.

Col. Carnegie stated that 11,000 tons of zinc is imported into Canada for use by manufacturers and about 5,000 tons of zinc white. He pointed out that these manufacturers would be materially assisted if the refining of zinc were commercially possible in Canada. Mr. Thompson stated that the possibility of treating zinc ores is more complicated than that of refining copper. Mr. Hedley questioned whether there would be sufficient high grade zinc ore to justify the establishment of a smelter using the Belgian process. Mr. Thompson spoke of large deposits of zinc ores at Seymour and Lynn Creeks, he stated that these were not yet developed.

Dr. Stansfield spoke of the experimental work that had been done in regard to smelting complex zinc ores in the electric furnace, and pointed out that the present proposal to use electrolysis was entirely distinct from this and appeared at present to be more economical.

Mr. Hedley considered that the Trail smelter would be a suitable place for the development of a zinc refinery.

It was stated that information with regard to the water power available for such purposes as copper refining was in the possession of the Dominion Government, the Chief Engineer of the British Columbia Electric Railway Company having been retained for this purpose.

The question of labour conditions was raised and it was stated that a great deal of trouble had been produced by the labour unions which are international and very strong, but that the situation was improving.

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2. *ANSWERS TO QUESTIONS UPON WHICH INFORMATION IS DESIRED RELATING TO INVESTIGATION RE COPPER AND ZINC REFINERIES IN CANADA.*

Vancouver Board of Trade,
May 17th, 1915.

David Carnegie, Esq.,
Ordnance Advisor, Shell Committee,
Drummond Building,
Montreal, Que.

Dear Sir:—Enclosed please find answers to questions left with the Mining Committee of the Vancouver Board of Trade, dealing with the establishment of a copper or zinc refinery in British Columbia. There are certain questions being forwarded to you with private information, through the President of the Board, Mr. Jonathan Rogers, and submitted to him by Mr. E. A. Hepburn, mining engineer, and a Member of the Committee.

Trusting that this information may be of great service to you in your work of investigation.

Yours faithfully,
W. A. Blair, Secretary,

GENERAL.

1\. Q. What in your opinion are the prospects for the establishment of a copper refinery in British Columbia that could be a commercial success?

A. Good, provided one gets the co-operation of Granby, which we consider essential. Britannia, Canadian Consolidated and B.C. Copper are important, but none of them essential.

2\. Q. What location or locations would in your opinion be the most advantageous, and why?

A. The neighbourhood of Vancouver, for the reason that it has the advantage of both water and rail transportation, and will have electric power at probably lower rates than elsewhere.

3\. Q. What are comparative costs in Canada, and the United States for:—

A. (a) *Labour?* Skilled labour is as cheap as in the United States. Unskilled labour is from 15 to 20% higher.

(b) *Power?* Power is cheaper here.

(c) *Fuel?* 50% higher here, but there is the prospect of the establishment of by-product coke-ovens on the coast which would materially cheapen coke, and improve the quality.

(d) *Cost of living?* Very little difference, if any.

4\. Q. What production of blister copper per annum would be needed to support a copper refinery on a commercial basis?

A. From 40,000 to 50,000 tons.

5\. Q. What quantity of zinc ore is necessary to insure the successful operation of a zinc smelter?

A. Unanswered.

6\. Q. What by-products would be available and what disposition could be made of them?

A. Paints, white-lead, zinc oxide, copper sulphate, antimony, and other usual by-products.

MINING.

A. *Copper Mining.*

1\. Q. What prospect is there of the copper production on the coast being increased?

A. Granby and Britannia will increase their production greatly and rapidly. Beyond these it is problematical. Granby production will of course include that of smaller mines. The copper production of the coast would be increased about fifty million pounds within one year, making a total of over one hundred million pounds.

2. Q. What properties now undergoing development give promise of adding to the coast production, apart from increases which may be expected from the mines now being operated?

A. Copper properties on Roche de Boule are becoming a factor, and there is promise of considerable production of copper ore of fair or even high grade, from that quarter. Properties at the south end of Moresby Island, Queen Charlotte group, may help in small measure, also Matsuea Co., Great Ohio, Red Rose, and with capital for exploitation there are big possibilities near Vancouver, in ores of Britannia type, of same formation, but virgin as to work done. Quatsino, too, has some promise.

B. *Zinc Mining.*

3. Q. What zinc prospects are known on the coast?

A. Lynn Creek and Quatsino have such.

4. Q. Have they ever produced ore, and how much?

A. None.

5. Q. Have you accurate information as to the tonnage available?

A. Undeveloped.

POWER.

1. Q. At what points on the coast is electric power now available?

A. Burrard Inlet, Howe Sound, and Lower Fraser River.

2. Q. Is it being utilized at all?

A. 250,000 h.p. used on lower main land.

3. Q. What capacity is lying idle?

A. 250,000 h.p.

4. Q. Where could the cheapest electric power be obtained?
   A. (Not explicit). Lower mainland.

5. Q. What would be the lowest cost per h.p. year, or per killowatt hour?
   A. From $10.00 to $24.00 per h.p. year; the latter being the outside price.

6. Q. How much would be available?
   A. Upwards of a half-million h.p.

FUEL.

A. *Coal.*

1. Q. What is the cost of coal at the pit mouth?
   A. Run of mine coal $3.00. Nicola Country coal $2.25.

2. Q. Have you any data on the actual cost of production?
   A. Cost varies, no reliable data, but approximately $2.75 per ton. Depends on management and condition of measures.

3. Q. What does coal cost at Ladysmith?
   A. (Answer to this question is being sent forward by President).

4. Q. Are the Vancouver coals good coking coals?
   A. (Answer to this question is being sent forward by President).

B. *Oil Fuel.*

1. Q. What does crude oil and what does fuel oil cost on the coast?
   A. From 85c to $1.10 per barrel, according to quantity supplied.

2. Q. What are the sources of supply?
   A. California and Peru.

3. Q. What is the equivalent quantity of each, crude oil and fuel oil, in comparison with one ton of coal from Nanaimo or Wellington Collieries?
   A. 3.5 to 3.6 barrels of oil equal to one ton of Wellington or Nanaimo Coal.

LABOUR.

1. Q. What are existing labour conditions on the coast? Union? Open shop? In what trades?

   A. All principal trades are Union.

2. Q. What is the prevailing scale of wages for skilled and unskilled labour in the various trades?

   A. Going from unskilled to skilled labour it runs brom 30c to 50c per hour.

FREIGHT.

1. Q. What are the existing rates on copper and zinc ores, and on blister copper from:—

   (a) *East Kootenay to Vancouver?* $5.00 per ton.

   (b) *Boundary to Vancouver?* $5.00 per ton.

   (c) *Boundary to New Jersey or Montreal?* $14.00 per ton of 2,000 lbs.

   (d) *Coast to Coast (by rail)?* No commodity rate at present.

   (e) *Coast to coast (by Panama)?* $12.00 per ton.

   (f) *West coast to European markets?* $30.00 per 2240 lbs. under normal conditions.

MARKETS AND MARKETING.

1. Q. Where would refined copper from British Columbia be marketed?

   A. At the present time the market would be Europe, but the market is shifting to Asia, which would be the future market for British Columbia.

2. Q. Where would refined zinc from British Columbia be marketed?

   A. Europe.

3. Q. What would be the influence on other Canadian industries if a copper or zinc refinery were established on the coast?

   A. The influence could not be other than favourable, and small factories would follow.

4\. Q. How will the United States copper refineries view the establishment of a refinery in Canada?

A. The United States would hardly look with favour on such establishment, but we are of the opinion that a Canadian refinery would cut too small a figure in the total American product to provoke real antagonism.

(Sgd.) N. THOMPSON,
Chairman of Mining Committee.

(Sdg.) W. BLAIR
Secretary of Board of Trade.

3\. *REPLIES TO QUESTIONS UPON WHICH INFORMATION IS DESIRED RELATING TO COPPER AND ZINC REFINING IN CANADA.*

A. E. Hepburn, Mining Engineer and Member of Board of Trade, Vancouver.

GENERAL.

1\. Q. What in your opinion are the prospects for the establishment of a copper refinery in British Columbia that could be a commercial success?

A. The copper production is now approximately 4,250,000 lbs. per month, and will increase rapidly within the next two years. The Granby at Grand Forks, the Granby at Anyox, and the Britannia Mines at Howe Sound, are all steadily increasing their output, and in two years will have doubled their capacity. The Marble Bay and other mines will swell the total. Large prospective deposits of copper ore are known to exist, that will average from 1·5% to 2·5% copper contents with fair gold and silver values. British capital properly directed under up-to-date management is the requirement. I would respectfully suggest that British interests employ a confidential agent or agents to report and obtain control of any such properties of merit with the view of developing to a stage where a complete plant would be warranted. At present all the copper matte and blister

copper produced in British Columbia is exported to America, and question very seriously owing to the ownership of these properties, as to whether British interests can obtain their output. There is no question in my mind that the Granby at Anyox will as a business proposition erect their own electrolytic refinery, whenever they in their wisdom consider it time. The same holds good with the Britannia Mines or any others of note in this province to-day. All these groups are controlled by foreign capital, and this should be a serious lesson, and one which should be remedied without delay. The markets of the world are open to British Columbia, and railway and steamship transportation facilities are of the best. The Panama Canal rates should allow British Columbia metal producers to compete and assist to supply the Empire with part of their requirements. Trade within the Empire is my motto.

2. Q. What location or locations would, in your opinion, be the most advantageous and why?

A. At the mine on salt water, as shipments are open to the markets of the world direct and the cathode copper would be produced cheaper at the mine.

3. Q. What are the comparative costs in Canada and the United States for—

(*a*) Labour?

(*b*) Power?

(*c*) Fuel?

(*d*) Cost of living?

A. (*a*) About equal in the Western States of Canada and America, but compared with the East, probably the latter is 15% cheaper. This will be remedied as the population increases by the introduction of industries and general development in immigration.

(*b*) Power can be generated at a low rate from $8.00 to $12.00 per h.p. per year.

(*c*) Coal in the Western States of Canada and America is more expensive, but the British Columbia coals are of a higher grade in all respects than the coals of the Western States of America. The run of mine coal on Vancouver

Island averages about $4.00 per ton, but no one to-day would use run of mine coal for generating heat for power, but would use washed pea or screenings or even sludge. Very cheap power could be generated if we had a modern by-product oven plant at the mine, and this would be warranted if a large undertaking was in progress, for a large supply of coke would be required regularly.

(*d*) About equal.

4\. Q. What production of blister copper per annum would be required to support a copper refinery on a commercial basis?

A. A small unit to start with a view to increasing plant as market conditions warranted. At present I do not see where a definite tonnage could be obtained quickly for reasons stated in my answer to Question 1. I would consider a unit of 15 to 20 tons of cathode copper produced per 24 hours a fair start and one of economic value.

5\. Q. What quantity of zinc ore is necessary to insure the successful operation of a zinc smelter?

A. It depends on market.

6\. Q. What by-products would be available and what disposition could be made of them?

A. The usual by-products.

MINING.

A. *Copper Mining.*

1\. Q. What prospect is there of the copper production on the coast being increased?

A. Every prospect only requires capital and good management. It is well known that large prospective deposits are only waiting legitimate development. The same mineralized zone as the Britannia has been traced for one hundred miles and one of the possibilities lie in this direction. Other mineralized zones are also worthy of careful examination. See reply to Question 1 "General."

2\. Q. What properties now undergoing development give promise of adding to the coast production, apart

from increase which may be expected from the mines now being operated?

A. See reply to Question 1 "General."

B. *Zinc Mining.*

3\. Q. What zinc prospects are known on the coast?

A. Quatsino, Lynn Creek, Malaspina Inlet and other parts of the province in or near the coast. All prospects, but worthy of development under proper directions. Large deposits in the interior are known in combination with lead and other metals.

4\. Q. Have they ever produced ore and how much?

A. No tonnage on the coast.

5\. Q. Have you accurate information as to the tonnage available?

A. No actual tonnage technically but every prospect of tonnage being developed with capital and proper management.

POWER.

1\. Q. On what points of the coast is electric power now available?

A. Vancouver, Victoria and adjacent districts.

2\. Q. Is it being utilized at all?

A. Yes, to a very large extent, but not to the capacity that could be supplied by any means.

3\. Q. What capacity is lying idle?

A. More than required, no limit within reason.

4\. Q. Where could the cheapest electric power be obtained?

A. From coal screenings, the coming fuel for generating heat power, also surplus gas from modern by-product coke ovens, etc.

5\. Q. What would be the lowest cost per h.p. year or per killowatt hour?

A. Can supply very cheap power. This absolutely depends upon the method used and many other considerations. $8.00 to $12.00 per h.p. per year.

6\. Q. How much would be available?

A. No limit.

FUEL.

A. *Coal.*

1. Q. What is the cost of coal at the pit mouth?
 A. Depends upon conditions locally and many other considerations. Would estimate about $2.50 per long ton for Vancouver Island.

2. Q. Have you any data on the actual cost of production?
 A. Varies, depends upon management and condition of measures.

3. Q. What does coal cost f.o.b. Vancouver Island?
 A.

Screened lump	$1.60 to $5.00
Run of mine	
Number 1 nut	
Number 2 nut	
Number 1 pea	
Balance	

Approximate analysis of the coal quoted:—

Moisture	2%
V. C. M.	38%
Fixed Carbon	54.5%
Ash	5.5%
Sulphur, under	2%
Phosphorous	negligible
B. T. U.	12,600

4. Q. Are the Vancouver Island coals good coking coals?
 A.

	WATER	V.C.	F.C.	ASH	SULPHUR	B.T.U.
1.	1.88	33.27	54.67	9.40	0.78	12672
2.	0.88	27.34	61.82	8.70	1.26	13881
3.	8.75	25.30	56.40	9.52	0.21	12567
4.	1.28	35.26	55.83	7.30	0.33	13199

1. Upper Douglas........0′ 0″ to 20′ 0″ and even 28′
2. Lower Douglas........2′ 6″ to 3′ 6″
3. Rider..................2′ 0″ to 4′ 0″
4. Wellington...........3′ 0″ to 6′ 0″

The whole of the seams do not appear to be present at any point in the coal field. Area approximately 650 square miles

No. 3 is the Wellington seam, and there is too much moisture. No. 2 is the Comox seam and has too much sulphur for iron smelting. In a modern by-product oven these coals should make a good coke. Further a modern by-product oven should produce from coal containing about 2% moisture and 27 to 35% V.C.M. 70 to 75% coke or 10 to 15% more than bee-hive ovens, yielding in by-products, 50 lbs. of tar, 24 lbs. of sulphate of ammonia and enough surplus gas to generate over 8 h.p. per ton of coal coked daily. By this method very cheap coke would be produced, about $1.75 per ton net cost. The profits from the by-products make the profit. $300,000.00 will erect plant to produce 100,000 tons of coke per year. Screenings are good enough for this purpose, and therefore cost per ton will be less. One of the greatest coal assets in the interior is the Bear River deposit now known as "Bowron River" forty-five miles east of Fort George. They are a rich bituminous by-product producing coal. Professor Galloway's son, of Cardiff, Wales, estimates 150,000,000 net tons and further states that bituminous coal is known for an area larger than Scotland surrounding Fort George. The coal croppings are 15 miles from the Grand Trunk Pacific with a grade in mine favour. The coal is remarkable for its low content in sulphur and ash. Further work will be done on the property this summer with a view of having a large test for all its true qualities. All the coking ovens in the province to-day are Bee-hive and are all out of date and a scandal to the province. The waste in consequence is enormous, for there is a market for all the by-products. The surplus gas alone should be an asset to any industry near the plant. In fact cheap power would induce industries to start. Another point few seem to realize is that in copper smelting the great reverberatory smelters are using coal dust for generating heat and power and for smelting their ore, and I am convinced that it is the coming fuel in modern copper smelters.

B. *Oil Fuel.*

1. Q. What does crude oil and what does fuel oil cost on the coast?

   A. The crude or natural oil is refined in California and the residue fuel oil is what is used here by the railroads, etc. Even this way of using it is wasteful of by-products. Cost per barrel from 80c to $1.25, the former price only for large contracts. As the maximum output of oil has been passed in California, the chances are that this price will gradually go up and in a few years, I have every reason to believe that the United States will put an export duty on all oils as they can use all their output. The question is now being considered by able American thinkers.

2. Q. What are the sources of supply?

   A. California and South America.

3. Q. What is the equivalent quantity of each crude oil and fuel oil in comparison with one ton of coal from Nanaimo or Wellington collieries.

   A. Approximately 3.5 to 4 barrels of fuel oil. Personally I have every confidence in coal as the coming power, and it will be to the advantage of our natural resources. Crude oil and fuel oil are now imported into British Columbia duty free, but have lately become subject to a small war tax. This is not fair to our own coal resources, and the government should impose a duty.

LABOUR.

1. Q. What are existing labour conditions on the coast? Union? Open shop? In what trades?

   A. Practically all Union.

2. Q. What is the prevailing scale of wages for skilled and unskilled labour in the various trades?

   A. From 30c per hour to 50c. The latter is skilled labour. These prices are certain to fall in due time, and are already doing so.

FREIGHT.

These questions have no doubt been replied to by transportation officials.

MARKETS AND MARKETING.

1. Q. Where would refined copper from British Columbia be marketed?

   A. In Canada, Russia, Orient and Great Britain via Panama.

2. Q. Where would refined zinc from British Columbia be marketed?

   A. Great Britain and Canada. Practically all shipments now go to the United States.

3. Q. What would be the influence on other Canadian industries if a copper or zinc refinery was established on the coast?

   A. Could not be anything but beneficial in every way.

4. Q. How will the United States Copper Refineries view the establishment of a refinery in Canada?

   A. Why should the British Empire not trade commercially in every way within the Empire, and so build up new industries to our mutual advantage and benefit. We as Britishers must develop our own mines and produce our own copper, zinc and other necessary metals, and by-products, and if it is advisable let the Government protect our own interests by a protective tariff. If foreign interests control our copper output and do not act fairly, then I would suggest an export tax in our favour. We have a perfect right to protect ourselves, if the necessity arises. In my opinion, if British interests will investigate the possibilities of the coast or province and develop the prospects on a sound basis, then we need have no fear of foreign interests, for in a few year we could control our own supplies. Why could not British manufacturers organize and agree to purchase refined copper at a fair price and one which would be satisfactory to the mine operator and himself? It surely could be arranged. Again why should some of the large users of refined copper in Great Britain not organize and find the capital to develop the mines, erect plants and ship the refined article to themselves? In this way expenses could be kept down to a minimum and all the profits go into their own pockets,

and which in turn would benefit everybody in the Empire. The serious point is that the shrewd Americans are now busy tying up our best resources, and it is time for the Britisher to wake up. They certainly, to my own knowledge, are looking around to-day to see what properties can be obtained under bond, not alone in copper and zinc but which in a sense is as important, our iron ores.

ELECTROLYTIC REFINING OF BLISTER COPPER 98%

The Multiple System is considered the best:

Cost of refinery complete to produce 40,000 lbs. per day, approximately $150,000.00

Cost of blister copper at mine, 8c lb....		160.00	per ton.
Cost of cathode making per ton of copper produced................		16.00	" "
Extraction of gold and silver from slimes.........................		1.00	" "
Cost of resmelting cathodes into ingots.		6.00	" "
Extras............................		5.00	" "
	$	188.00	" "

The industry could start with a reasonable unit and grow as business warrants. With a plant of even this capacity, one would require a large tonnage in process all of which is a liability. If the refinery was at the mine the anodes could be produced cheaper.

ARTHUR E. HEPBURN,

Vancouver, B.C., May, 1915.

4. REPORT ON COPPER REFINING

Vancouver, B.C., February 27th, 1915.

The Chairman of the Mining Committee,
The Board of Trade.

Your sub-committee was appointed to gather data relative to the advisability of establishing a copper refinery in the Province of British Columbia. After communicating with the principal parties interested in the mining and smelting of copper and other ores in the province, we beg to report as follows:—

1st. In order to comprehend the importance of the copper mining industry to this province, we may state that according to the report of the Minister of Mines for the year ending 31st December, 1913, the value of the total mineral production of the province for all years up to and including 1913 was $460,443,920 and of this amount, copper produced $80,818,051, or practically 18% of the total mineral production of the province. In 1913, 46,460,305 pounds of copper was produced and the total value was $7,094,489 which is $2,000,000 over the value of the gold production, and only $300,000 under the total value of the coal production. In spite of these most satisfactory figures, it is a regrettable fact that not one pound of this copper is refined in British Columbia, or even in Canada. A small proportion is refined at Tacoma in the State of Washington, but the great bulk of the matte or blister copper is shipped to the Nicholls Refinery Company of New York.

It may interest you to know that this Nicholls Copper Co. at Laurel Hill, N.Y. has a capacity of close on 400,000,000 lbs. of refined copper per year and according to Mr. A. C. Flumerfelt, one of the directors of the Granby Smelting & Power Co., a charge of 3 cents per lb. is allowed by smelters for cost of refining and to cover loss on impurities, amounting to about 4% and as the copper production of British Columbia is approximately 50,000,000 lbs., the refining of electrolytic copper would mean a saving to the province of approximately $1,500,000 now paid to foreign refineries.

Your sub-committee has communicated with the managers of the principal mining and smelting companies in B.C., as well as with experts in Great Britain and elsewhere and the concensus of opinion is that the time is not quite opportune for the establishment of a refinery in British Columbia.

In a personal interview with Mr. F. M. Sylvester, general manager of the Granby Consolidated Mining & Smelting Co., he concurred in the opinion expressed by Mr. R. H. Stewart and others, as stated in the accompanying letters. He agreed, however, with your sub-committee that the subject was of the utmost importance to the province. The output should steadily increase and when it reaches approximately 100,000,000 lbs. per year, the establishment of an electrolytic refinery in the province would be justifiable.

Cheap water power, one of the principal essentials to the operation of a refinery we have in abundance in B.C. The high cost of "especially unskilled labour" is against the proposition but that will regulate itself in time. The principal market for refined copper is at the present time in Europe and the eastern United States. Japan is a producer of copper and as a matter of interest we may mention that mines in Japan are not generally worked as joint stock companies, but are mostly family properties which have descended to their present owners, from their ancestors and so far as is known, only one mining company in Japan, has its shares dealt in on the stock exchange, and mines are worked like other industrial undertakings, and owing to the abundance of cheap labour, they are yielding profits on exceedingly low grade ores.

The present production of copper in Japan is about 90,000,000 lbs. per year, but this does not supply the demand and Japan is an importer of refined copper. In spite of this fact, however, Japan operates a modern electrolytic copper refinery which refines about 37,000 tons of copper per year.

We have pleasure in attaching herewith copies of the correspondence we have had with various interested parties.

All respectfully submitted,

(Sgd.) J. B. MATHERS,
(Sgd.) N. THOMPSON.

The Consolidated Mining and Smelting Company of Canada, Limited.

Trail, B.C., December 16th, 1914.

N. Thompson, Esq.,
Care Cammell Laird & Co., Ltd.,
Vancouver, B.C.

Dear Sir:—

Answering your letter of December 12th, addressed to Mr. Stewart. Mr. Stewart is at present in the east and will not return for about two weeks.

With reference to a copper refinery at the coast: the first question would be to find out whether you could get sufficient copper to refine to make the scheme feasible, for instance, find out whether the Granby people could ship you copper to refine, and at what rate they could afford to give you the copper.

I hardly think you would be able to compete with the large American refineries, tonnage being a large factor in obtaining low costs in copper refining. There is practically no difference in freight between shipping blister copper or refined copper and gold. In fact, the freight favours shipping the precious metals in the form of blister copper.

In connection with our own output. This is extremely high in gold and would require to be mixed with some other product to get sufficient silver to part the gold. It would also take a lot of money to finance the handling of this material.

I will give your letter to Mr. Stewart on his return and see whether he has any suggestions to make in the matter.

Yours very truly,
S. S. BLAYLOCK.

The Consolidated Mining and Smelting Company of Canada, Limited.

Trail, B.C., January 7th, 1915.

Nicol Thompson, Esq.,
Manager, Cammell, Laird Co., Ltd.,
Vancouver, B.C.

Dear Sir:—

Referring to your letter of December 12th, to which Mr. Blaylock replied on December 16th, I am of the opinion that it

would not be profitable to establish a copper refinery in Western Canada, at present. Conditions for the refining of metals are more favourable on the Eastern coast, due to the cost of labour, power, acids, and all the essentials of copper refining.

The difference in weight between blister copper and refined copper is about 2% or 3%, and the market in the west would be so extremely limited at present that there would be no gains to offset the advantages of refining in the east.

As regards our own output, supposing we made blister copper it would probably be impossible to sell it even to a large refinery owing to its high and variable grade in gold and silver and to the resulting difficulty in sampling. If our copper were to be refined, it would, on this account, have to be done by ourselves. If it were possible to ship it without the gold, it would be cheaper to refine in the East. For these reasons I am of the opinion that it is premature to consider the question at the present time.

Yours truly,

R. H. STEWART.

The British Columbia Copper Company, Limited.

Greenwood, B.C., December 16th, 1914.

N. Thompson, Esq.,
Vancouver, B.C.,

Dear Sir:—

I have your letter of 12th inst., in which you ask for information regarding a copper refinery in British Columbia.

In the first place, there are very few smelting concerns operating in B.C., at the present time, that are not under contract for their copper output, whether in the form of blister copper or copper matte, and how long these contracts run, we are unable to state.

As to ourselves, we are shut down, but are still under contract to deliver quite a tonnage of blister copper to a certain refinery in the east. The Granby Co., being so closely allied to the Nicholls Copper Co. who have a refinery at Laurel Hill, New York, probably would prefer to refine their copper back there, instead of giving it to a local concern.

The only refining concern which is producing matte in B.C. (at least to my knowledge) is the Consolidated Mining & Smelting Company, at Trail and we feel certain that if they were able to secure a large amount of copper, whether through the purchase of ores, or matte, or blister copper, direct, it would pay them to instal an electrolytic copper refinery at Trail, as they already have a lead refinery at that point, so that a small refinery would save them considerable money. This would work no direct benefit to other copper producers, for the simple reason that freight on refined copper from the refinery to the Atlantic seaboard would be charged the producer in any event, and as the difference between blister copper and refined copper is rarely over 2%, the saving in freight would be negligible. Personally, I do not see where a copper refinery could pay expenses in B.C. at this particular time. If, in the future, all copper producers could market their product in the province, it might be different.

Trusting this information, which is very meagre at best, will be of service to you, I am,

Yours very truly,

OSCAR LACHMUND,

General Manager.

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351 S. Marguerita Ave.,

Alhambra, Cal., January 22nd, 1915.

Nichol Thompson, Esq.,

Vancouver, B.C.

Re Copper Refining.

Assuming the conditions in copper mining to be about the same as when I left British Columbia, with the exception of the new operations at Hidden Creek and the temporary closing down of the Granby smelter and the Greenwood smelter, the production of copper is about the same. The interests controlling these corporations, are varied while the product of all of them is contracted for for terms of from one to five years ahead, while the product of the Granby Co., which is controlled by the Nicholls Refining Co., of New York, could not be diverted from its present route, so that were market and other conditions satisfactory for the establishment of a refinery on the coast, I am afraid that very little of the present output of copper would be available for such a project.

The disposition of the different plants is about as follows:—

Trail: Ship to Tacoma	Granby; Ship to New York.
B.C. Copper; Ship to New York.	Marble Bay; Ship to Tacoma.
Britannia; Ship to Tacoma.	Hidden Creek; Ship to New York.

All of this product is probably tied up under long contracts so that you could not hope to get sufficient copper to run a refining plant at the present time.

The electrolytic refining of copper also involves the separation and refining of silver and gold, requiring large amounts of capital and no market at hand for the finished copper product, for these and may other considerations I do not think it would be either advisable or profitable to build a refinery on the Coast under present conditions.

Yours very truly,
THOS. KIDDIE.

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30 Fairfield Building.
January 13th, 1915.

Nichol Thompson, Esq.,
City.

My dear Mr. Thompson:—

In reply to your query about the establishment of a copper refinery at the coast, my opinion is that it could only be profitably operated as an independent concern, under the following conditions.

First, that you have the co-operation of the large producers, namely Granby, B. C. Copper and Canadian Consolidated.

Second, that you can be assured of a market for your product, or at least a major portion of it independent of New York.

Third, that you secure a favourable rate for power and a site that ensures favourable transportation rates.

As refining would involve the shipping of the gold and silver to its market, either as a refined product or in the shape of doré bar, at a high transportation cost, it is manifest that if the bulk of product must go east, it is cheaper to transport the blister copper, containing the precious metals, also the cost of labour and supplies would certainly be against the western plant.

Regarding the process to be used. There is no process as good in every respect as the electrolytic. In Japan the most modern plant, at Ashyo, is electrolytic.

Yours very truly,
ROBERT R. HEDLEY.

The Mining and Engineering Record.

September, 1913.

AN ELECTROLYTIC REFINERY FOR THE PACIFIC COAST.

A. C. Flumerfelt, one of the directors of the Granby Consolidated Mining, Smelting and Power Company, is quoted as authority for the statement that the operations of that company will ultimately result in the establishment of a refinery in British Columbia. As matters stand the copper output of the province has to be shipped to eastern refineries. principally that of the Nichols Copper Company at Laurel Hill, N.Y., which has a capacity of close on 400,000,000 lbs of refined copper per year.

A charge of three cents per lb. is allowed by smelters for cost of refining and to cover loss on impurities amounting to about 4%. As the copper production of British Columbia amounts to over 50,000,000 lbs. and is steadily increasing, the refining of electrolytic copper would mean a saving to the province of $1,500,000 now paid to foreign refineries.

Cheap power is the principal essential to the operation of a refinery, and British Columbia has water-powers running to waste in abundance. The cost of refining varies from $8.00 to $20.00 per ton.

Mr Flumerfelt states that ten years ago Mr. Graves, the Managing Director of the Granby Consolidated and he were authorized to secure a smelter site near Vancouver with a view to the ultimate establishment of a refinery, and the only reason for the plan not being carried out was the want of an assured supply of blister copper. That objection is now removed.

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5. *LYNN CREEK ZINC DEPOSIT.*

A report was presented to the Commission which had been furnished by Mr. Newton W. Emmens, mining engineer to the

Western Dominion Land and Investment Company, Ltd., of Vancouver with reference to the zinc deposits on the west fork of Lynn Creek. The report, which was dated August 5th, 1912, gives a very favourable account of the deposits of zinc in this locality and states that if these are properly developed they should result in a very valuable mine; very little data are given with regard to the amount or composition of the ore.

An article in "The Daily Province," Vancouver of June 25th, 1915, refers to the ore at Lynn Creek. It is urged that this deposit contains a very large amount of ore which is sufficient to justify the organization of a zinc smelter in the neighbourhood of Vancouver. It is stated that development of the Lynn Creek property will commence in July.

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6. *T. SCOTT ANDERSON EXTRACTION PROCESSES FOR COPPER AND ZINC.*

Letter, May 31st, 1915, from T. Scott Anderson to Col. David Carnegie, states that Mr, N. Thompson, of Vancouver, has asked him to write with regard to the production of electrolytic copper direct from the ore, and also a zinc ore treatment. Gives some particulars of these processes.

Letter of Nov. 27th, 1912, from T. Scott Anderson, Sheffield, England, to Messrs. N. Thompson & Company, Vancouver, B.C., in reference to the treatment of ores from Lynn Creek. Refers to chemical process for recovering zinc and copper from these ores, obtaining the zinc as a sulphate, and sulphuric acid as a by-product. One ore treated showed a recovery of 98% of the copper, 94% of the zinc (as oxide) and 88% of the iron.

Letter of August 10th, 1914, from T. Scott Anderson to Messrs. N. Thompson & Company, refers to processes for refining copper matte.

Memorandum of June, 1911 from T. Scott Anderson giving details of his process for the electrolytic production of pure copper direct from the ores, and of tests made on this process.

These memoranda are very lengthy and do not strictly bear on the present investigation.

SECTION VI. VISIT TO BRITANNIA.

1. *MEMORANDUM BY COLONEL DAVID CARNEGIE OF A VISIT TO THE BRITANNIA MINING AND SMELTING COMPANY, ON WEDNESDAY APRIL 14th, 1915.*

The Commission met Mr. Donnahue, assistant to the manager, who gave particulars of the supply of ore, method of concentrating, and conditions of sale of their concentrates to the Tacoma Smelting Company. He favoured the starting of a copper refinery near Vancouver, provided it could give as good rates as the Tacoma Company. He stated that his Company was considering the erection of a smelter near the mine, and gave particulars of the amount and cost of water power available, also cost of coal and other supplies.

The memorandum is as follows:—

Drs. Wilson, Stansfield and myself left Vancouver at 9.15 a.m. by boat and reached the mine about 12.30.

Mr. Donnahue showed us over the works at the Beach.

They employ about 400 or 500 workmen at the Beach and at the Mine inclusive, consisting of almost all nationalities, the common labour being done by Japanese. The total inhabitants at Britannia Beach and at the mines, including women and children, is nearly 1,000.

Every provision is made for the comfort of the workers. There is a large store which would do credit to Vancouver. Every facility is found for the domestic supplies and the general comfort of the people. There is a hospital and a doctor, together with a trained nurse. There are two schools and also social and recreative opportunities for enjoyment.

Household and domestic supplies can be obtained at the stores without cash, payment for same being deducted from the wage bill of the employee. This method of obtaining stores is not compulsory but is taken advantage of by many of the work people, particularly the unmarried men. The works are built amongst beautiful surroundings, the mill being on the beach and the mine three or four miles up the mountain at an altitude of nearly 3,500 feet. The

ore is at present brought down by a gravity rope way in cars, but a new incline 5400 feet long, with an altitude of 1800 feet is being equipped with cars to carry 10 tons of ore. Mr. Donnahue informed us that they had contracted with the Tacoma Copper Works to supply them with their entire output of ore concentrates and that it would be two years more before the contract expired. They are charged $2.75 per ton flat rate for the refining of their concentrates, plus $2\frac{3}{8}$ cents per lb. for copper refining, the Tacoma Company retaining for their own profit 10 lbs of copper per ton of ore or concentrates supplied. They are also penalized if the ore contains over 8% of zinc and also if the ore contains silica exceeding 10% of the amount of iron in the concentrate, but excess of iron is paid for. Mr Donnahue saw no reason why a copper refinery could not be established on the coast and he did not think there would be any opposition to such a project by the American refineries. He believed that it would not matter to whom his company shipped their ores or concentrates so long as they received a suitable price. It was a question of dollars and cents. He said that his company would ship to Vancouver just as soon as to Tacoma. He stated also that they had had under consideration the locating of a smelter and they considered that the South Valley nearby their present location was the most suitable for water power which they hoped to secure. Their present output is 800 tons of ore per day. They are now mining from 15 million to 18 million lbs. of copper per year. They are increasing their equipment at the mill with the object of treating lower grade ores of about 1% copper contents. The average amount of copper in their ores as mined at the Fairfield Mine is approximately $2\frac{1}{2}$%. They have three claims called the Bluff, the Jane and the Fairfield, all close to each other, on all of which mining has been done. The Bluff contains a low grade copper ore with a percentage of zinc in it. There are nearly two million tons of this ore, particulars of the analysis of which Mr. Donnahue has arranged to send us. The Jane mine contains more Pyrites with a little iron. The Fairfield contains copper pyrites, the copper being nearly 3%. They installed a MacDougall furnace and a Wetherill magnetic separator for treating the ore, but it was not put into operation. Their working hours are 8 hours per day in the mine and nine hours on the outside. They at present generate about 1,500 k.w. by water power costing from $3.50 to $3.75 per h.p. year. These

operating costs do not include the capital costs. They have also a 500 k.w. low pressure steam turbine plant and have on order from Fraser & Chalmers, Kent, a 2,000 k.w. low pressure steam turbine plant.

The units are as follows:—

In the upper plant—

1 200 k.w. electric generator.
1 100 k.w. electric generator.
1 150 h.p. compressor.
1 175 h.p. compressor.

In the milling plant—

1 150 k.w. rotary generator from a 700′ water head.
3 Generators, each 200 k.w. from a 700′ water head.
2 150 h.p. electric generator.
2 100 h.p. electric generator in the milling plant.

Beach plant—

1 400 h.p. rotary generator from 1900′ water head the pressure being 800 lbs. per square foot at wheel.

FUEL.

The cost of coal is $5.65 in the lump at the pit for domestic purposes.

Oil costs $1.10 per barrel of 35 imperial gallons delivered on the beach and $1.00 at Vancouver. The cost of Australian coke was about $13.00 per ton. The ore concentrates contain about 15% of copper. They are briquetted at Tacoma, gypsum being mixed with the concentrates, after which they are charged into the blast furnace for smelting. No roasting is done. Mr. Donnahue stated they could easily make refined copper for 8 cents. Tacoma costs include everything and were a little lower than 8 cents per lb. for refined copper. Tacoma shipped a good deal of her copper to Japan. Mr. Donnahue did not see any reason why copper could not be refined as cheaply in British Columbia as in the United States. The rate to Tacoma per ton for copper concentrates was 66 cents, the distance being about 168 miles by water. the rates for some freights were as low as 50 cents.

POWER.

The approximate cost for a 4,500 k.w. generator and water wheel plant is about $50.00 per h.p. The cost of mining the tunnel in the hill by contract was $20.00 per running foot.

COST OF PRODUCTION.

$2.05 for ore per ton.

5.1 cents for the ore per lb. of copper produced.

Cost of milling, 64 cents per ton.

Cost of traming, 22 cents per ton.

The length of the tramway is approximately 11,200 feet in two units of 6,000 feet and 5,200 feet. The cost of marketing the concentrates is $12.00 per ton. This cost includes freight at 74.4 cents per ton of dry ore. Unloading, 16 cents per ton. Smelting treatment at Tacoma, 71.03 cents per ton.

Mr. Donnahue very kindly showed us the lower part of the mill where the concentrates were being finished. They have 9 Hardinge conical mills and one tube mill through which 800 tons of crushed ores are passed per day of 24 hours. These mills scoop up the crushed ores, which are about the size of small peas, water being fed in all the time with the ores. The lining of the mill consists of short lengths of 4″ flat bottom rails, about 4″ long; these are placed in neat cement first coated around the inside of the drum to a thickness of 2″, the rail being pressed into the cement after which a second coating of cement, making 4″, is put on. This lining costs about $125.00 and lasts one year, instead of three months which was the usual life of the Chrome steel linings formerly used. They take 72 hours to reline and pure cement is the only material used along with the short lengths of rails. The speed of the mills is about 50 r.p.m. The crushed ore passes from these mills into a mineral separation unit of eight cells, the first two of which are used as emulsifiers. A certain proportion of creosote, gas oil and crude oil are allowed to drip into the first cell to promote the separation of the concentrates from the gangue. The creosote takes the place of tar formerly used. The oil costs amount to about 5 cents per ton of concentrate produced.

2. *BRITANNIA MINING AND SMELTING COMPANY, BRITANNIA BEACH, B.C.*

Letter of April 23rd, 1915, from Mr. J. W. D. Moodie, Vice-President and General Manager, to Col. David Carnegie, giving replies to a series of questions in regard to the establishment of a copper refinery in Canada.

Mr. Moodie states that their power costs, during the past two years, have been in the neighbourhood of $45.00 per annum per h.p. and that further increases are being made in the size and efficiency of their power plant.

The questions and answers follow:—

1. Q. How far have you gone in considering the treatment of your ores to matte and blister copper, and by what methods?

   A. Consideration has been given at times to the question of erecting a smelter for the treatment of our own and customs ores but on account of the heavy expenditures necessary in order to place present plant on a larger tonnage basis no further action was taken, deferring this until later date.

2. Q. Have you considered the question of refining blister copper in Canada, and what were your conclusions?

   A. The question of refining blister copper in Canada has not been given serious consideration.

3. Q. Do you favor refining in Canada? If so why? If not, why not?

   A We favor the refining of our copper in Canada providing this can be done on basis as favorable as provided by present contract with smelting company.

4. Q. What location, or locations would, in your opinion, be the most advantageous for a copper refinery and why?

   A. Britannia Beach, in our opinion, offers a very favorable site for copper refinery for many reasons, the chief ones being contemplated cheap power costs and water transportation for the crude and finished product.

5. Q. What would it cost to refine copper at the point you consider the best location for a refinery, and how would these costs be distributed among the items; interest on investment, overhead, power, fuel, labour, marketing?

A. It is our understanding that power is the principal operating expense and tonnage available the chief factor in cost of production. Unfortunately we are not in possession of sufficient data to make proper reply to your query.

6. Q. Would you favor an amalgamation of the principal copper producers in British Columbia to control one central refining plant.

A. It is our opinion that an independent refinery operated under an economical management could with more success handle, under proper contracts, the copper of the various companies than by the co-operative control system.

7. Q. Would your company be prepared to contribute blister copper to such a plant, and under what conditions?

A. The contribution of our copper to a refinery would, of course, be dependent upon the erection of smelting plant, and following which the securing of favorable contract terms.

8. Q. What production of blister copper per annum would be needed to support a copper refinery on a commercial basis?

A. We have heard various figures submitted in answer to this question, ranging from fifty to one hundred million pounds per annum, and regret that we are unable to furnish definite information.

9. Q. How long will it be before your company will be free to make new contracts for the treatment of your blister copper?

A. Our present contract with smelting company is dated February 15th, 1913, and is for a period of ten years, with provision, however, that same may be terminated at end of five years, should we decide to erect our own smelter. Further stipulation is also made that in the event of termination at end of five years, contract shall continue for six months additional; also, covering periods of shut down, such as under our present operating condition, resultant from recent slide.

10. Q. In what way do you think that the Government could best assist in the establishment of a refinery?

A. By encouraging mining companies through power concessions, etc.

SECTION VII. REPORT FROM PRINCE RUPERT.

The Board of Trade of Prince Rupert, B.C. communicated to the Commission a report by Mr. A. C. Gardé on the resources of copper and zinc ores within the district tributary to Prince Rupert. This report which is appended in full and dated, June 3rd, 1915, deals mainly with the supplies of copper ores in the north of British Columbia and the advantages to be gained by locating a copper refinery at Prince Rupert. This city, the western terminus of the Grand Trunk Pacific Railway could receive ores and concentrates from a mining district about 700 miles long and 500 miles wide. The Anyox smelter in this region, already contributes one third of the output of copper in British Columbia. There are some ores containing zinc in combination with lead, silver, etc., and it is considered that the electro-thermic smelting method will ultimately be found suitable for their treatment. The smelting of copper ores at Anyox is described, and it is recommended that the blister copper from Anyox and other points in the district should be refined at Prince Rupert.

REPORT ON THE RESOURCES OF COPPER AND ZINC ORES WITHIN THE DISTRICTS TRIBUTARY TO PRINCE RUPERT.

By A. C. Gardé.

PART I. PREFACE.

The President and Members,
Board of Trade, Prince Rupert, B.C.

Gentlemen:—

In accordance with your request, I beg to submit my condensed report on the resources of copper and zinc ores within the districts tributary to Prince Rupert, together with notes on the present facilities for smelting and the eventual refining of such products as are required in the manufacture of munitions of war, now under consideration by Colonel David Carnegie of the British War Office.

Government Reports.—That it is impossible for me to do justice to so expansive a subject in the time at my disposal is evident. Even a brief description of properties on which work has been done, and shewing of ore made, would make a long article. In this respect I refer you to the excellent reports, edited and published in Victoria, B.C. by the Provincial Mineralogist, Mr. Wm. Fleet Robertson. Also many valuable memoirs issued by the Geological Survey of Canada, and the Department of Mines, Ottawa, under the able supervision of Dr. Eugene Haanel.

Facts and Commercial Aspect.—I shall therefore, confine my remarks as much as possible to accomplished facts, with special reference to developed mines and promising claims within your district, together with such further data, along the lines of smelting and refining, as may be useful to Colonel Carnegie and his Committee in suming up the general situation as it presents itself in Prince Rupert and Northern British Columbia, from a commercial and industrial point of view.

Central Geographical Position.—By reference to the attached map of British Columbia it will be readily seen that the Skeena Mining Division proper, extending about 200 miles to the north, and 150 miles to the south of Prince Rupert, is bounded by the Pacific Ocean to the west, and the Omineca Mining Division to the east. The size of this comparatively small territory has been mapped out and limited by the Provincial Government with a special view to convenience in the administration of the same, and for that reason only covers a part of the ore-producing area to which I shall refer in the following report as "Your District".

Prince Rupert District.—On the map, I have outlined in purple ink the "greater" district of which your city for several economic reasons is the natural and strategic centre.

1. By virtue of its central location in the district.

2. On account of its being situated at tide water and provided with excellent harbour facilities, also a magnificent dry dock.

3. Perhaps the most important point of all, Prince Rupert is the Pacific terminus of the Grand Trunk Pacific Railway—an undertaking of national importance—completed since the outbreak of the European War.

Prince Rupert Hinterland.—To the east, your district, which is traversed by the GrandTrunk Pacific Railway, extends

through the central portion of the province, and reaches well on towards the Yellowhead Pass in the Rockies, taking in the whole of the Omineca, also part of the Caribou and the Peace River Mining Divisions. Bella Coola to the south, and the Queen Charlotte Islands to the west are both situated within a radius of 200 miles of Prince Rupert.

Cassiar District.—To the north the Portland Canal, the Stikine, the Atlin, and the Liard Mining Divisions—known as the Cassiar District—will all find a natural outlet by water haul to Prince Rupert.

Alaska and The Yukon.—This also applies to the coast and the islands of south eastern Alaska—known as the Pan Handle—as well as to the Yukon Territory beyond Atlin.

Economic Conditions.—It is not unreasonable to predict that the bulk of ores mined and concentrates produced within the above mentioned large district, which covers an area of approximately 700 miles in length and 500 miles in width, and from a mining point of view represents the best part of the province of British Columbia, will eventually gravitate to Prince Rupert by way of rail or water, and more particularly so if smelted and refined in transit. Plants for these purposes could be most conveniently located in Prince Rupert.

Progress in the north.—To any one not familiar, or only slightly acquainted with the progress made in Northern British Columbia in the last decade these statements may seem rather exalted, and it must be admitted that since developments in your district were started, and your city first placed upon the map—about eight years ago—it has been a case of "what you hoped and expected to do." The completion of the railway, inadvertently delayed for several years, now an accomplished fact, has altered all this. *You have become a producer.*

Production.—Your debut among the copper producers of the world is a definite and distinct success, and the first step in the right direction—the stride of a young giant.

Anyox Smelter Data.—I have taken considerable pains to compile authentic data on the subject, and append a resume of my conclusions. Since March, 1914, when the new smelter at Anyox, Granby Bay, owned by the Granby Consolidated Mining Smelting and Power Company, Ltd., was "blown in" until the end of the year 1914, 260,000 tons of 2.2% copper ore were mined

from the Hidden Creek properties on Observatory Inlet, at a cost of about $1.00 per ton, and smelted at the Anyox plant;

producing	12,000,000 lbs. copper, valued at	$1,500,000.
	130,000 ozs. of silver, valued at	71,240.
	2,800 ozs. of gold, valued at . .	56,000.
	Total	$1,627,240.

Present Production.—This represents nearly one sixth of the total output of copper in Canada, and 30% of British Columbia's production for the year 1914.

Future Production.—Even this record will be broken in the near future, as a fourth furnace and auxiliary power is now being added to the plant, and there is every reason to believe that by the end of this year your district will contribute *one third* of the Canadian annual production of copper, which last year amounted to 75,738, 386 lbs., and *one half* of the British Columbia output, which in 1913 amounted to 45,791,570, and in 1914 to 41,221,628 lbs.

Granby Co.—It is of interest to note that the Granby Co. has for a number of years been the pioneer company in mining and smelting low-grade copper ores, on a large scale at Phoenix and Grand Forks, in the boundary district, southern British Columbia, but it was not until 1912 that the Hidden Creek Mines at Observatory Inlet in the Skeena Mining Division were bonded by them and a campaign of systematic testing and development work undertaken. After having thoroughly investigated and diamond-drilled this valuable group of claims, the property was purchased and extensive development work started.

Diamond Drilling.—166 diamond drill holes were put down with a total footage of 43,591 feet in the course of this development work, and options taken on several other promising groups in the same locality. At the present time, the Granby Company owns more than 5,000 acres of mineral bearing lands and is continually adding to its holdings.

$3,000,000 Invested.—Their actual capital invested in mines and smelter equipment in your district exceeds $3,000,000.

20 Million Tons Developed.—In round figures this enterprising company has developed 20,000,000 tons of ore averaging

1.4% copper, and thirty cents combined gold and silver values per ton. One half of this tonnage will assay, approximately 2.2% copper and yield 40 lbs. of copper net per ton of ore smelted. As compared with the Phoenix ores in southern British Columbia —from which recovery of only 17 lbs. of copper per ton is made— the Granby holdings at Hidden Creek may well be regarded as high-grade, and it is principally for this reason that operations were kept up at Anyox after war was declared in August, 1914, while the company's smelter at Grand Forks was temporarily closed.

PART II. MINING.

Remarkable Coast Line.—Prospecting for minerals on the coast of British Columbia is by no means an easy task, owing to the luxuriant growth and heavy mantle which is found everywhere; but is materially aided by the irregular shore line and numerous deep inlets.

Fjords.—These inlets, like the Fjords of Scandinavia, cut deep into the mainland and expose the formation for as much as one hundred miles. Portland Canal and Observatory Inlet are excellent examples. Observatory Inlet divides at the head into two branches, known as Hastings and Alice Arm, and, as shown on the map, stretching respectively in a northerly and easterly direction. This Fjord may be compared to a huge open cross-cut with drifts extending both ways.

Prospecting and Shipping.—The inland frontage thus opened has not only been a great boon to the prospector in making new discoveries of minerals, but also to the Coastwise Steamship Companies on account of the excellent waterways thus afforded, and by which any vessel may approach the wharves that have been constructed at the various shipping points. I have already mentioned the importance of the Hidden Creek Mines situated at the head of Observatory Inlet, Granby Bay.

Pioneer.—When Mr. Myron K. Rogers eight years ago undertook to develop this group he became the founder of the most recent and promising copper camp in British Columbia. Incidentally he is also the pioneer of the Nickel Plate Mine, at Hedley, B.C., in the Similkameen district, a property which is universally regarded as the most valuable gold mine in Canada, if not in North America.

Bonanza Group.—Another group of six claims, known as the Bonanza Group is situated on the Creek of the same name two miles to the south of Hidden Creek. A great deal of exploration work in the shape of diamond drilling has been carried out for several years by the Granby Company, to whom the property was under option. This option has now been exercised. The surface croppings are very extensive, and indicate the presence of a wide mineralized zone consisting of copper and iron pyrites, with considerable quartz. Whether these sulphides and their matrix will lend themselves to the same process of pyritic smelting as the Hidden Creek Mines remains to be seen. Judging from the amount of work done and the large tonnage of ore reported to have been determined by numerous drill-holes put down, it is more than likely that another producer will soon be added to the list.

The Outsider's Group.—Is situated in Maple Bay, Portland Canal, and has the distinction of being the first copper producer in the district. It was originally bonded to the Brown Alaska Co. of Hadley, Prince of Wales Island, Alaska, and approximately 15,000 tons of 3% copper ore was shipped to their smelter at Hadley in 1906. Unfortunately the above company which was not a strong one came to grief owing to the fall in price of copper that year, and since that time there has been nothing further done with the Outsider's Group, notwithstanding its good showing of ore and shipping facilities. Recently it has come into prominence again on account of its proximity to the adjoining group, known as the Maple Bay Group.

Maple Bay Group.—This group, also situated at Maple Bay, consists of about 40 claims and covers an area of nearly 2,000 acres. It joins the Outsider's Group at Maple Bay and is at the present time under a long term option to the Granby Company. It is apparently one of those huge copper and iron sulphide deposits like the Hidden Creek and the Bonanza mines, and on which considerable diamond-drilling will have to be done to test the extent of the mineralized zone. Work of this kind was carried on last year, and is being continued this year by the Granby Company.

Kitsaulte Copper Camp.—At the head of Alice Arm on the Kitsaulte River, and 17 miles from tidewater, several promising discoveries of iron and copper sulphides have been made. The

pyrite and chalcopyrite croppings would seem to indicate the presence of a mineralized zone which appears to be more than one-half mile wide, and can be traced on the surface in a north-westerly direction for nearly five miles. It is bounded on the southwest side by red porphyry, and on the northeast side by slates. The ore occurs in a quartz gangue, sometimes in the quartzite, and at other times interspersed with diabase intrusions. A series of groups have been staked on the various showings but comparatively little work has been done as the out-croppings are too big to enable the average prospector to do more than penetrate the capping. Most of the assessment work has therefore been expended on trails, and in preparing for bigger exploitations and diamond-drilling. The Red Point Group, consisting of four claims is the premier location. On account of the heavy iron-oxide stain this property can be seen a long way off when coming up the valley. It forms the backbone of a spur of the mountain-range in which the Kitsaulte River has its source, and is situate between that river and Evindsen Creek. Several ore bodies of chalcopyrite have been exposed here by stripping. On the first one, measuring from 14 to 16 feet in width. Mr. Donald G. Forbes, Mining Engineer for the Government took a sample in 1913 which assayed copper 5.9%, silver 2.5 ozs., gold $6.00. On the second showing, which is 350 feet from the first, a sample two feet of ore assayed: copper 4.6%, silver 0.6 ozs., gold 80c. Further up on the mountain side Mr. Forbes took sample No. 1 from another lens of ore measuring 20 feet across, assaying: copper 8.5%, silver 1.3 ozs., gold $7.60, besides other samples yielding good returns both in copper and gold. In addition to the "Red Point" group a dozen others have been staked in the same zone. The "Combination," "Dan Patch," "Vanguard," "Copper Cliff," "Copper Moon," and "Sun" claims, etc. On most of these properties the showings are quite sufficient to justify further developments, but the existing transportation facilities on the Kitsaulte River are anything but favourable for shipping ore. In time it may be good business to build a short railroad from the canyon down to Alice Arm by following the riverbank, but the immediate demand is for a wagon road on which supplies can be hauled into camp. I understand that the Provincial Government is arranging to start work on a road this season, more particularly on account of important developments at the Dolly Varden Silver mine situ-

ated immediately to the south of the above mentioned prospects, and on which a concentrating plant is under serious consideration. This feature will assist materially in bringing the new copper belt to the fore. In the same district, seven miles from Alice Arm, at the headwaters of the Chigitsquit river, a tributary to the Kitsaulte, a promising group of claims known as the "Red Bluff" have been located. The outcroppings are quite similar to the Red Point, and other claims in the vicinity of Alice Arm, and like these are still in the prospecting stage. This same pertains to locations made on the Illiance River farther east, and on Roundy Creek to the south. Both streams empty into Alice Arm at the head.

Hastings Arm.—Here a number of locations have been staked within the past two years and good samples of copper ore have been brought out by prospectors, indicating that the district immediately to the north of Alice Arm in time may become of importance as a source of copper.

Southeast Alaska.—On Prince of Wales Island the Granby Company has acquired the "Mamie" mine, and developed 335,000 tons of ore averaging 2.25% copper. The ore is valuable as a flux in the smelting operations at Anyox. The "It" and "Dean" mines, situated on the same island have also been taken over by the Granby Company. This property will average from $15.00 to $10.00 per ton in copper and gold values. At least 5000 tons of ore have been developed, and the property is fully equipped to produce 30 tons per day. The "Midas" mine situated on Prince William Sound, near Valdez, is also owned by the Granby Company. The estimated tonnage developed is 160,000 tons averaging 4% copper, and $10.00 in gold. This property is equipped with a plant capable of handling 100 tons of ore per day which is shipped to the Anyox smelter.

Skeena River, G.T.P.Ry.—Within a distance of 171 miles from Prince Rupert, on the Grand Trunk Pacific Railway, the Montana Continental Development Co. at Tramville, near Skeena Crossing, has installed a complete power plant at the Roche de Boule mine and developed approximately 30,000 tons of copper ore with encouraging results. The new company took over the mine in November, 1913, at which time approximately 10,000 tons of ore were blocked out. Last year the work was closed down during the winter for four months while ore

bins were being erected in Prince Rupert for shipping purposes. Regular shipments to the Granby smelter at Anyox are now kept up at the rate of about 50 tons per day. It is stated by the management that the assay values run from 8 to 10% copper, with $3.00 in gold and silver, and that shipments will be increased to 100 tons per day as soon as everything is in running order. The pay-ore consists of copper sulphides and grey copper. In view of the good results obtained in so short a time, and considering that this is the first copper produced on the G.T.P. Railroad, it is of particular interest to Prince Rupert, and recognized as the fore-runner of many others now in various stages of development, for instance, the "Great Ohio," the "Highland Boy," the "Red Rose," etc. Near Kitselas, at Mile 107 on the G.T.P. Railway, at a station known as Usk, the La Cordillera Mine has also commenced to ship on a small scale. A trial car of very good looking copper ore is now on the way to the Anyox smelter. In the same vicinity on the Copper River, which is tributary to the Skeena, several copper claims have been staked not far from where the well known iron and coal claims are situated.

Yukon Territory.—By continuing the journey northwards to Skagway and Whitehorse we find that copper ores of exceptionally high grade are mined at the "Pueblo" mine and that representative shipments have been made from here for the past two years. In the same belt there are many good copper prospects of which the "Best Chance" might be mentioned. In the Atlin District and at "Rainy Hollow" finds of high-grade copper ore have also been made and the indications for active mining operations in the far north are indeed favourable.

Queen Charlotte Islands.—Only one mine, the "Ikeda" is at the present time shipping copper ore in small lots to the Anyox Smelter, but on Moresby Island, there are several other properties now under development, and it is expected that some of these will soon become productive.

Kitimaat and Douglas Channel.—In this district numerous mineral locations have been recorded, and on several of these good samples of both copper and silver-lead-zinc ores have been obtained. Only the necessary assessment work has so far been carried on.

Portland Canal.—This district, of which the city of Stewart is the centre, is well known for its silver, lead and zinc mines, and considerable work has been carried on for a number of years towards developing same, especially by the Portland Canal Tunnels, Ltd., and Portland Canal mines. Copper is often associated with the ores of this camp, and widely distributed. At the Red Cliff mine, situated at Lydden Creek, Bear River district, the principal values are in copper and gold, and two or three lenses of good grade chalcopyrite have been located here and blocked out. Shipments from this property are likely to commence at an early date, as it is well equipped with a 10-drill compressor plant, also ore bunkers located on the Portland Canal Short Line Ry. leading to Stewart. Renewed activity at this property would encourage developments on many promising copper prospects in the same vicinity on Lydden and American Creeks.

Mixed Ores.—The Stewart Mining District will no doubt in time add much to the mineral production of British Columbia, but has not advanced as rapidly as expected on account of the complex, or rather mixed, nature of the ore-bodies found. It may therefore be of interest to analyze briefly the principal causes for delay.

Difficulties.—1. After making due allowance for the usual extravagant statements expressed in every new mining camp, the fact remains that important ore deposits exist in the Portland Canal district. Unfortunately the values are not confined to one or two minerals; but often an admixture of four or five, viz:—lead, silver, zinc, gold and copper, besides iron.

2. Many prospectors and investors not familiar with complex ores and "illusive" assay certificates were lead to believe that all (or practically all) of these values could be recovered and would be paid for by the smelting companies to whom the ores were consigned.

3. It is a well-known fact that a lead smelter will not pay the miner for copper and gold values, unless these metals are present in appreciable quantities, nor is it possible for the copper smelter to pay him for the lead when the bulk of it is lost by volatilization in the smelting process.

4. As to the zinc, we know that all smelters, with the exception of those that have specially constructed plants for the

recovery of zinc by means of intricate methods of distillation and condensation, look upon the presence of this metal as a nuisance, providing the ores contain more than 8 or 10% of zinc. If these ores are accepted at all they will be subject to a penalty of 50c for each unit above the first 8 or 10%.

5. It should furthermore be remember that there are no zinc smelters in British Columbia yet, capable of treating these mixed zinc ores successfully, and that the silver-zinc concentrates and silver-zinc ores which at the present time are being exported from the Kootenays in reality are silver ores and for that reason able to stand heavy freight charges and import duties to the United States.

6. The Portland Canal and Skeena River zinc ores do not contain appreciable silver values like the Kootenay ores, and are therefore not able to overcome the high freight and duty charges to Colorado and Missouri.

7. Should the mining conditions warrant the cost of a mill it might be advisable for the mining companies to erect a concentrating, or separating plant on the premises, whereby the zinc could be eliminated or saved as a separate product, and the lead brought up to a higher grade ready for shipment to the lead smelter. Again, where the ores contain values in copper or gold, additional smelter products might be made and in this way little difficulty should be experienced in securing markets for the various individual products on account of their greater value.

8. I do not wish to deprecate the art of concentration, but after all is said and done, with this class of ore the most perfect concentration scheme would only be a relief not a cure. Water concentration means losses in values, extra risks, experiments, a trained crew, and a considerable outlay of capital. Custom plants may overcome some of these objections, but in doing so may possibly introduce other equally tedious elements, besides, after this is all completed the zinc concentrates have not been disposed of and we still have them on our hands, providing of course that they were saved at all.

9. Where the ore is of the crypto-crystalline type and not amenable to any known process of concentration, or separation there is no hope for success except by smelting.

10. In my opinion the real solution of the above vexed question of treating badly mixed silver, lead, zinc and iron ores will not come until electro-thermic smelting has been made a success.

Electro-thermic Smelting.—This will depend very much on experiments which are now being carried on by Mr. Woolsey McAlpine Johnson of Hartford, Conn. Mr. Johnson stands to-day at the head of the metallurgical profession in dealing with the treatment of zinciferous ores by means of electro-thermic smelting and has accomplished what is expected to become of real value to all zinc miners. He has already made a success with a one-ton furnace, and is now perfecting a ten-ton plant. The Federal Government, Department of Mines, is much interested in his achievements, and I understand that an arrangement with regard to the use of Mr. Johnson's patents has been consumated. I know that the mining fraternity in British Columbia would be pleased to have this confirmed. We are all aware that zinc mines and prospects are scattered over the entire province, and in need of better methods for economic treatment, and we would welcome Mr. Johnson here if he succeeds in solving the above problem. Northern British Columbia not only offers an exceptionally large field for metallurgical operations, but, as I shall point out in the following, can furnish cheap hydro-electric power which undoubtedly is the first principal to be considered in establishing any kind of electro-thermic works. Several excellent sites on water and rail are obtainable near Prince Rupert.

PART III. SMELTING.

CONTINUOUS COPPER SMELTING AND CONVERTING PROCESS.

Pyritic Smelting.—A noteworthy feature in connection with at least several of the larger ore bodies that have been discovered and developed in and about Observatory Inlet and Alice Arm is, that they are amenable to pyritic smelting. By this, in a general way, is meant a fusion process in which, so far as possible, sulphuretted constituents of the ore are utilized as fuel and slag-forming material, besides serving as a collector for copper, gold, silver, etc. A high percentage of sulphur and iron in the ore is

essential, but there are also many other conditions required for the successful operation of this process, which on this account, has not always proved a commercial success. The Anyox smelter has now passed the experimental stage. By drawing and mixing ores from two large bodies in the mine a suitable smelting charge is obtained, and only 5% coke to ore is used in the three 50 by 360 inches blast furnaces to produce a matte averaging between 16 and 17% copper.

Metallurgical Success.—This is a great achievement. It is almost the realization of the metallurgists' dream of thirty years, and while Anyox is not the only place in the world where pyritic smelting is practised successfully, it is probably the largest plant of its kind, and one of the few where the combination of *all* economic conditions has been taken advantage of from the very beginning, to insure a commercial as well as a metallurgical success. A lucid description of the Granby Company smelters, written by Dr. A. W. G. Wilson, Chief of the Metal Mines Division, Ottawa, is published by the Department of Mines, and will be found of much interest.

Bessemerizing Copper Matte.—After pyritic smelting the next operation is bessemerizing the 16% copper matte. This process is in reality an evolution of the method employed in bessemerizing steel, and is carried out by charging the matte, while still in a molten condition, directly into three huge specially designed cylindrical tilting furnaces called converters.

*Copper Converters.**—The steel shell of the converter is protected on the inside with a thick lining of crushed quartz and clay. An air blast under 12 lbs. pressure is introduced through one of the converter trunnions and after repeated blowing and tilting of the converter the sulphur and iron contained in the matte becomes oxidized. While the bulk of the sulphur passes off, into a flue just above the throat of the converter, as sulphur dioxide, the iron changes into ferrous oxide, and combines with the silica contained in the acid lining of the converter. In doing so it forms a basic slag, and by tipping the converter this slag is poured off into pots, thereby leaving a fairly pure cuprous

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*The copper smelter at Anyox uses basic-lined converters of the Great Falls type. The lining is magnesite brick. Silica is supplied by charging silicious ores or quartz into the converter.

A. W. G. W.

sulphide (white metal) in the vessel. The last stage of the converting process now takes place by resuming the blowing until the remaining sulphur is burned off. If this is skilfully carried out only metallic copper with *one or two percent.* of impurtities, plus the precious metals will remain in the bottom of the converter. The charge is now ready to be drawn and cast into ingots, which is accomplished by means of mechanically operated casting machines.

Low Cost of Production.—On account of the reduced fuel bill and cheap hydro-electric power generated at Falls Creek, together with low mining costs and efficient plant, the Granby Company is able to produce copper at a price just a little lower than anyone else. It is estimated that during this year copper will be produced at Anyox and delivered in New York for 7½c per lb. Prince Rupert is particularly fortunate in having a company of this calibre to pioneer this important copper camp of your district.

Blister Copper.—During the process the liquid copper dissolves a certain amount of the sulphur dioxide, which escapes while the metal is cooling in the moulds. This escaping gas leaves a blister-like surface on the ingots, and for this reason copper at this stage of bessemerizing is known in the trade as blister copper; it will assay from 98½ to 99% pure.

Products for Refining.—The annual production of blister copper and matte in British Columbia amounted during 1914, to approximately 28,420,000 lbs., and was made at the four smelters, Trail, Grand Forks, Greenwood and Anyox, of which 43% was contributed by Anyox. From the above it will be seen that the present output of copper available for refining in British Columbia is approximately 29,000,000 lbs. per annum. In addition, British Columbia exported during 1914 approximately 800,000 lbs. of copper contained in raw ores from Texada Island, and 12,000,000 lbs. contained in concentrates produced at the Britannia mine, near Vancouver, all of which was shipped to smelters in the United States. There are no physical reasons why Texada ores and Britannia concentrates could not be smelted, or otherwise treated in British Columbia, and no doubt arrangement will be made before long to establish suitable reduction works at the Britannia mine. I estimate that the production for next year will be at least 36,520,000 lbs., which is equal to an increase

of 25%, or 50 tons of refined copper per day. This tonnage might therefore be taken as a basis for establishing an electrolytic refinery in Prince Rupert, capable of handling the entire British Columbia output, and would correspond closely to the present imports of manufactured and crude copper, which in 1913 amounted to 41,011,961 lbs., and in 1914 to 28,230,812 lbs.

Distribution.—Blister copper from all inland smelters must eventually gravitate to the coast—be it the Atlantic or Pacific. This very fact shows clearly the important position of Prince Rupert, situate as it is on tidewater, within a few hours of Anyox, and able to deliver the refined metal to European markets via the Panama Canal, at the same time permitting shipments by rail direct to industrial centres in the East, where it can be manufactured into various forms for home consumption.

With regard to the production and refining of copper in eastern Canada the situation is quite different, as nearly all of it is smelted in conjunction with associated nickel ores. The bessemer matte thus produced requires special treatment and refining similar, but not the same, as the British Columbia blister copper. At the present time this matte is forwarded to Great Britain and the United States for separation and refining by electrolytic methods, but the prospects for home refining seem fair, and a suitable site for the erection of such works will no doubt be selected in Ontario ere long.

PART IV. COPPER REFINING

Fire vs. Electrolysis.—The art of copper refining may be broadly divided into two methods—furnace refining, and electrolytic refining. The first method is founded on the scorifying effect of cuprous oxide upon the base metals contained in a bath of molten copper. It is carried out in a reverberatory furnace by extraneous fuel whereby the crude copper ingots are melted and air blown into the bath. Cuprous oxide rapidly forms and dissolves in the bath. The blast must be under perfect control in order that it may be stopped just before the point of saturation. In this way oxygen is carried to all parts of the molten bath, and when there are any metals present which are more easily oxidized than copper, the cuprous oxide is reduced back to copper, and the oxides of the impurities are formed.

If these oxides are not soluble in the molten copper they will rise to the surface and may be removed by skimming and eliminated as a dross. In practice this purification can only be carried to a certain point, and where the blister copper is relatively impure, and especially where it contains values in precious metals exceeding $10.00 per ton, the above method is neither applicable nor economical. In British Columbia nine-tenths of all the copper produced is derived from sulphide ore-bodies of a more or less complex nature. Converter products resulting hereform are therefore not of the same purity as blister copper produced from native copper deposits as found in the Lake Superior and Michigan districts, and fire refining will not easily eliminate the last twenty or thirty pounds of impurities such as sulphur, arsenic, antimony, bismuth, etc., contained in a ton of crude copper.

Conductivity of Copper.—Should these remain the conductivity as well as ductility of the copper becomes seriously impaired, and consequently less valuable. For instance, if one-third of one per cent of arsenic or antimony remains in the finished product its conductivity, or in other words, its capacity for transmitting electric energy *is reduced by one-half*, and refining by the second method, viz:—electrolysis, becomes essential.

Electrolytic Refining.—The process of refining copper by the electrolytic method may briefly be described as ordinary copper electro-plating on a large scale where the impure metal is used as an anode, and the pure copper as a cathode in a solution of acidified copper sulphate, called the electrolyte. Approximately 75% of the electrolyte is water, 15% to 20% sulphate of copper (blue stone) and from 5% to 6% sulphuric acid. These proportions vary according to conditions, but in all cases the solution is kept at an even temperature of about 70° F. to prevent crystallization. An electric current is constantly passed through the electrolyte with the result that the impure copper anode, which represents the positive pole, is dissolved and chemically pure copper deposited on the cathode, representing the negative pole, while the impurities, consisting of practically all the arsenic, antimony, bismuth, lead, tin, nickel, etc., are dissolved or thrown down together with the insoluble precious metals, as a black residue. This residue, known as silver mud, is afterwards collected in the bottom of the tank and treated independently, either on the premises or at the Federal Assay Office as the case may be.

Anodes.—On arrival at the refinery the crude copper is usually given a preliminary furnace refining, and cast into anodes, unless this has already been done at the copper smelter, as it sometimes is. The anodes are generally 2 feet wide, 3 feet long, and 1 inch thick, and rarely weigh more than 300 lbs. The actual refining is carried out in wooden tanks about 8 feet long, preferably grouped in units. In a plant capable of refining 37 to 40,000,000 lbs. of copper per year or 50 tons per twenty-four hours, several hundred tanks would be required. Their number depends on the system used, also on the size of anodes. In the "multiple" system of refining the tanks require to be lined on the inside with sheet lead, while in the "series" system asphalt and cement, or other non-conducting material will answer the purpose. It is not the intention here to enter into the merits of the diverse methods of refining, or to furnish a description of a 50 ton plant. An outline of one of the largest refineries in America will convey a general idea.

Anaconda Refinery.—In 1895 the Anaconda Copper Mining Company, of Butte, Montana, completed the first copper refinery in the west. The late Marcus Daly, then Copper King of Montana, realized that he was paying the Baltimore Copper Refinery Company too much for refining his blister copper, and, after spending a million dollars or so in building an up-to-date refinery with a daily output of 150 tons of electrolytic copper, he succeeded in securing a substantial reduction. I was on the engineering staff of the Anaconda Company at the time. The multiple system of refining was introduced. In this the electrodes are alternately arranged so that a positive anode is connected with a negative cathode and suspended in the tanks with a clearance of about one inch. The cathode on which the refined copper is deposited consists of a thin sheet of pure copper. The electric current leading from the shunt-wound dynamo is conducted by means of pure copper bars. The time required to replace anodes is about six weeks. During the operation it is necessary to keep the electrolyte in constant circulation. Compressed air is used to advantage in this respect. Where the cost of labour is high it is necessary to reduce the expense of manual labour, and place electric travelling cranes of five tons capacity overhead in the building in such a manner that whole tank loads of anodes and cathodes can be lifted at one time.

Final Melting of Cathodes.—When the heavy deposited cathodes are ready for final melting into commercial copper ingots they are charged into a 50 ton reverberatory refining furnace similar in construction to the furnace used in the preliminary refining of blister copper and anode making. The process is known as "poling" and skilful handling is necessary, as the copper at this stage is apt to pick up impurities from outside sources, for instance, sulphur from the fuel, or iron from the rabbles. When this operation has been carried to just the right point the metal, now known as "tough pitch" has an even instead of a slightly depressed surface. Its fracture shows a fine texture of silky lustre and beautiful reddish hue, and will assay as high as 99.95% pure, and comply with all standard tests on conductivity. The process is completed by ladling the copper into moulds forming ingots which can be shipped to any part of the world to be drawn into wire or rolled into plates.

Purifying the Electrolyte.—The electrolyte must be kept in good condition, otherwise it will have a bad effect on the deposited copper besides increasing the resistance of the bath. When the solution becomes too impure it can be recrystallized in a separate plant for further use. This plant may be an adjunct to the refinery if local conditions, markets for bluestone, etc., are favourable.

Sulphuric Acid.—Victoria, B.C. manufactures 95% sulphuric acid from sulphur imported from Japan, which can be delivered in Prince Rupert at a cost of $25.00 per ton, but this is not the only source of supply. Should a market for sulphuric acid develop in northern British Columbia, raw material in the form of iron sulphides of excellent quality exist in large quantities in Hidden Creek Mine, Observatory Inlet, also on the Ecstall River, 35 miles south of Fort Essington, in the immediate vicinity of Prince Rupert. Reference hereto has been made by Dr. A. W. G. Wilson in his memoir No. 167, pages 85-86, dealing with pyrites in Canada. By taking the above conditions into consideration I believe that strong sulphuric acid can be profitably manufactured in this district and delivered at the proposed refinery for $15.00 per ton. Even this figure may be materially reduced if the Hall process for desulphurizing ores for the recovery of sulphur should prove a commercial success.

Fuel Oil.—Fuel oil with a gravity test of 70° Baume is sold in Prince Rupert by the Imperial Oil Co., Ltd., for 3½c per imp.

gallon, or approximately $1.25 per bbl. This company has recently spent one-quarter million dollars on the erection of a wharf, and several large storage tanks, adjacent to the Grand Trunk Pacific dry dock. The capacity of the two tanks set aside for storing the above grade of oil is 4,500,000 gallons. Fuel oil is used exclusively for the locomotives and steamboats owned by the Grand Trunk Pacific Ry. Co. This company, on account of its large consumption has a special rate, considerably below the above price, and should therefore be able to generate power at a very low figure. The oil is remarkably free of sulphur.

Coal.—The price of coal per long ton delivered in barge loads at Prince Rupert will range from $5.25 to $5.75 for lump coal, $4.75 for nut size, $3.75 for pea, and $2.00 for slack. The last item is worthy of special attention, as the latest practice in reverberatory furnace work is to use coal dust, or slack mixed with the ore charge in place of burning coal grates as formerly. The above figures on coal are based on transportation from Vancouver Island in barges at 75c per long ton.

Water Powers.—A very important feature in connection with the selection of a refinery site is the question of cheap power, generated by water, and in this respect Prince Rupert is well provided. Through my professional connection with the Prince Rupert Hydro-Electric Co. it has been my privilege to investigate this matter, and by their permission I am able to state authoritatively that there are at least six practical sources of water power within 50 miles of this city, which, if harnessed, would aggregate 108,866 h.p. as follows:—

Location.	H. P.	Drainage Area	Approx. Length of Trans. Line	Cost of Dam per H.P.
1. Khatada River......	30,636	60 sq.Mi.	44 Mi.	$16.00
2. Brown & McK. Lakes	28,150	60 " "	40 "	13.50
3. Falls River.........	20,454	100 " "	45 "	12.65
4. Union Bay..........	14,544	....	35 "	7.95
5. Thulme River......	11,450	....	20 "	11.16
6. Georgetown........	3,630	....	13 "	17.34
Total h.p...........	108,864			

All of these powers have been carefully surveyed, and the topography plotted. Their storage capacity, drainage area, water-

sheds and run-offs have all been observed and tabulated. Large sums of money have been expended for several years in securing the necessary engineering data to base calculations on, and the magnitude of the task will be appreciated more fully when considering the primary nature of the work in a "terra incognita." There are several unique features peculiar to this coast; the copious and uniformly distributed annual precipitation, the mild climatic conditions, with open harbours all the year round, as well as the melting glaciers and snowfields, that are constantly contributing to the annual run-offs, are a few of the characteristics.

City Power Plant.—The city of Prince Rupert, at a cost of $543,200.00 has, within the last year, completed a very efficient hydro-electric power plant at Woodworth Lake, five miles from the city.

Special Rate on Power.—This plant is designed to develop 3600 h.p. At the present time there is a surplus of 1000 h.p., which, I believe, after making careful enquiries, could be obtained for electrolytic copper refining purposes at a special rate of *one-half of one cent per kilowatt hour*, i.e., on a load factor of 100 per cent. A twenty-four hour service without interruption is an essential feature of the refining process. That one-half cent per k.w.h. on a load factor of 100% is a very low rate and practically represents cost, will be appreciated more fully when expressed in dollars per electrical h.p. per year, viz:—$32.67.

Attention is called to the fact that unless special mention is made the yearly rates stipulated by most municipalities and companies are universally based on 35% or 40% load factors, which means that an 8 or 9 hour shift constitutes a day. This would be out of the question in metallurgical work of the above kind. If a co-efficient of 40% is substituted in the Prince Rupert rate, for the purpose of comparison, it can readily be figured that the quotation in reality equals an *annual rate of $13.00 per e.h.p.* There are not may places in Canada where better terms for power can be obtained, especially when remembering that this power is available *now* and could, if necessary, be doubled and trebled by adding another unit, for the specific purpose of copper refining or electro-thermic smelting of zinciferous ores, as has been mentioned in the second part of this report. When I was in Anaconda it cost seven times as much to generate power from an inferior lignite coal mined at Belt, Montana.

Power Required.—The electrical energy required in refining one pound of copper by electrolysis depends largely on the current density used, that is to say, the number of amperes that will pass for each square foot of cathode surface. Where power is cheap and the anodes comparatively free from such impurities as bismuth, antimony, arsenic, etc., a high current density may be employed to advantage. In the absence of a complete analysis of the Granby blister copper and other important data appertaining to the choice of system it will be advisable to make a fair allowance for power. I estimate that a consumption of 0.2222 h.p. hours for each pound of copper dissolved and refined would be a liberal factor to base calculations on; 0.154 h.p. hour is the theoretical co-efficient. Following this out we find that the thousand h.p. now available in Prince Rupert will be sufficient to take care of 108,000 lbs per 24 hours, or nearly 40,000,000 lbs. per annum, which is 11,500,000 lbs. more than all the copper smelted and exported from British Columbia during 1914; and equal to the approximate tonnage of manufactured copper re-imported into Canada in various forms for local consumption.

Copper Exports.—In other words, practically the entire copper output of Canada, amounting, in round figures, to 75,000,000 lbs. per annum, is shipped abroad to be refined, smelted, or otherwise treated, and approximately one-half is returned to Canada and finds its way back through various channels of industry and art. Statistics show that about one-half of the total Canadian copper is produced in Ontario and the other half in British Columbia. Two refineries—one in the east, and one in the west—each with a capacity of 50 tons per day would therefore be able to take care of the entire Canadian production of copper-nickel matte and blister copper, and should be built in units to suit the future increase. I have already mentioned that the methods of refining the two products differ sufficiently to require separate treatment. While the subject of home refining is of vast importance to the British Empire its nature is so complex that it reaches beyond the power of individual companies or even Provincial Governments to undertake the adjustment. It affects many channels of trade and commerce that cannot be diverted by ordinary means, and requires extraordinary conditions, like the present European conflict, for all parties to realize the necessity of retaining the resources of Canada within the Empire. It is a question in

which the Imperial, the Federal, and the Provincial Governments are equally interested and their assistance is needed as much as the co-operation of the mining, smelting and transportation companies.

The Lead Bounty.—From a British Columbia standpoint the subject is not a new one. Twelve years ago the lead producers of this province were confronted with similar conditions. As the chairman of the British Columbia Silver-Lead Association at that time, and one of the writers calling the attention of the Dominion Government to our peculiar strait, I can speak with authority on the subject. For years we were obliged to ship our high-grade silver-lead ores to the United States, and pay a duty on same, because we had no lead refineries in Canada. Our friends in the transportation business have always cherished the "long haul" as it means one-half cent per pound going, and at least one cent per pound coming back as a finished product. To offset the American duty on lead ores the Dominion Government in 1903 granted a five years bounty of 75c per 100 lbs. of lead ($15.00 per ton), to the Canadian miner direct, providing the ores were mined and smelted in Canada. This Act, which was afterwards renewed for a further period of five years, saved the silver-lead mining industry in British Columbia. It also stimulated other industries, especially zinc mining. The Consolidated Mining and Smelting Co., Ltd., a strong Canadian concern at once established an electrolytic lead refinery in conjunction with their smeltery at Trail, B.C. and have ever since been able, not only to smelt and refine all the lead ores of the Kootenays, but also to recover new by-products such as antimony and sulphate of copper in addition to the precious metals derived from the argentiferous galena. History is now repeating itself, and while there are features peculiar to the copper business that differ from those of lead, we know that it is within the power of the Government to introduce measures that will develop and benefit the industry without being drastic in their effect.

Refinery Sites.—Electrolytic copper refining plants can be located in the centre of a large city without inconveniencing the population any more than would a factory or nickel plating works, as there are no fumes or obnoxious gases expelled in the process which cannot be taken care of by the exercise of ordinary precautions. In this respect a refinery differs materially from a smelting plant. In Prince Rupert there are several excellent

sites within the city limits well suited for locating a refinery so that it can be reached by water as well as rail. Both the Provincial and the Dominion Governments own water front lots here, but these cannot be compared with a possible site at the G. T. P. dry dock, as this establishment is fully equipped with docks, tracks, machine shops, boiler shops, foundries, electric power, compressed air, a modern steam plant and power house, huge cranes, derricks, etc., as well as tools of every possible kind, and now ready to engage in business. To build and complete a refinery at this place would take less than six months time. The total area covered by the dry dock is 22 acres, of this approximately five acres in the southwest corner are not occupied at present. I estimate that one-half of this space would be sufficient to accomodate a 50-ton refinery, and answer the purpose admirably. I have good reasons for believing that satisfactory arrangements can be made with the Grand Trunk Pacific Ry. Co. to lease this site at a nominal rental, and I am firmly convinced that there is none better to be obtained within the Dominion. No serious difficulties should be encountered in concluding amicable arrangements, since the Federal Government is financially interested in the dry dock enterprise, and the railroad company on their part are anxious to develop any and all new industries in Northern British Columbia, especially those of such vital importance as mining, smelting, and refining.

Cost of Labour.—This treatise would not be complete without making mention of the labour market at this coast, and the standard wages paid. I can hardly do better than quote the prevailing wages paid at the dry dock, viz:—

Skilled labour, carpenter, machinist, etc. . .	45c per hour.
Handy men	40c per hour.
Unskilled labour	33c per hour.

Plenty of labor can always be secured in Prince Rupert, and generally the conditions and living expenses are very much the same here as in the large cities to the south.

Refinery Construction.—A good quality of timber, such as the native Douglas Fir, would answer very well in the construction of a refinery. Sulphuric acid fumes from the electrolyte have a tendency to destroy steel structures, and the entire plant including refining tanks, should therefore be built of wood. For

this reason no time need be lost in waiting for building material in Prince Rupert.

Cost of a 50-ton Refinery.—I estimate the total cost of erecting a 50-ton refining plant complete in Prince Rupert, according to the above description at $250,000. This includes the following principal items:—

1. All buildings, foundations and tanks for refining.
2. Auxiliary plant for making anodes, melting scrap and casting ingots.
3. Dynamos for depositing copper electrolytically.
4. Rotary converters for transforming city current.
5. All the necessary copper bars and plates for conductors.
6. Complete circulating apparatus for electrolyte.
7. Electric travelling cranes and track for refining building, etc.

In the above estimate I have excluded the generating plant for electric power, as I am recommending to make use of the 1000 electric h.p. now available at the city hydro-electric plant, as mentioned on page 127. Nor have I calculated on a separate refining and parting plant for the silver residues, as I believe that the Federal Assay Office could handle the precious metals and by-products to better advantage.* This would increase their daily output of gold and silver at least $1000.00, but certain additions to the present equipment require to be made.

Cost of Refining Per Ton.—As to the net cost of refining 50 tons of blister copper per day in Prince Rupert by electrolysis (multiple system) I have compiled as much data as possible since the matter was submitted to me and estimate that it can be done for $600.00 per day or $12.00 per ton of copper refined. This is based on electric power at one-half cent per k.w. hour for continuous service, and allowing for a daily consumption of 1000 electric h.p., also for a 10% depreciation on the entire equipment plus interest on capital invested in buildings, and stock of copper locked up, at 6% per annum. The extra cost of treating residues is approximately $1.00 per ton. The freight rate on the refined copper to eastern points will be about $12.00 per ton.

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*The Federal Assay Office at Vancouver is not equipped to handle the by-products produced by a copper refinery and could not accommodate a refiining plant at its present location.

A. W. G. W.

RECAPITULATION.

The principal reasons why Prince Rupert is the natural centre for copper refining on the Pacific coast:

1. Geographical centre and gate-way to richest mining section of B.C.
2. Transcontinental railway terminus.
3. Prominent Pacific seaport.
4. Unexcelled harbour and dry dock facilities.
5. Most conveniently situated building site in Canada.
6. Low cost of hydro-electric power—now available.
7. America's largest pyritic smelter within 100 miles.
8. Labour of all kinds plentiful.
9. Fuel of all kinds obtainable at low cost.
10. Building material, lumber, etc., convenient and cheap.
11. Sulphide ores for acid manufacture plentiful in vicinity.
12. Distributing depot for fuel oil in northern B.C.
13. Mild climatic conditions all the year round.
14. Healthy surroundings and normal living expenses.
15. Six months would complete a 50-ton plant, everything necessary being at hand.

In submitting this report for your consideration I desire to express my appreciation to Mr. F. S. Wright—your Commissioner —also Messrs Wm. T. Donnelly and C. N. Crowell of the Dry Dock and Mr. Albert Davidson, General Agent, G.T.P. Ry., for courtesies shown.

ALFRED C. GARDÈ, B.Sc.,
Consulting Mining Engineer,
Member Can. Mg. Inst.

Prince Rupert, B.C.,
June 3rd, 1915.

SECTION VIII.
MEDICINE HAT, ALBERTA; AND FIELD, B.C.

1. *MEDICINE HAT.*

NOTES WITH REGARD TO THE POSSIBILITY OF LOCATING A ZINC SMELTER IN THIS DISTRICT.

Medicine Hat was visited about the 4th April and information was received with regard to the supply of natural gas and other fuel. The following memoranda were obtained:

2. *COAL AND NATURAL GAS AT MEDICINE HAT.*

COAL

Deposits of coal are to be found in many localities in the neighbourhood of Medicine Hat, but the only two places where coal is mined in commercial quantities in the immediate neighbourhood are at the Ansley Coal Mine and at Redcliff.

The Ansley Coal Mine is situated about six miles west of the city in portions of Sec. 5, Tp. 13, Range 6; Sec. 6, Tp. 13, Range 6; Sec. 1, Tp. 13, Range 7 and Sec 32, Tp. 12, Range 6, all west of the 4th Meridian. There are two seams of coal in this district; one $4\frac{1}{2}$ feet thick at a depth of 190 feet below the surface and one $6\frac{1}{2}$ feet thick at 250 feet below the surface. According to analyses made by various authorities, this is good quality lignite coal. There is no Government report on the Ansley mine, but analytical reports made on this coal by several independent sources give the following results:—

Moisture	Volatile Matter	Fixed Carbon	Ash	Sulphur
5.3%	36.5%	52.9%	5.3%	....

This coal has been used with success for various purposes in this city, and has been used extensively in Calgary and in many of the smaller towns along the line. The mine is in good condition, and, up to the present, no gas has been encountered.

NATURAL GAS.

The gas area exploited extends from Bassano, ninety-five miles west of Medicine Hat to Dunmore, nine miles east. The flow at Dunmore is the same as at Medicine Hat, so that it is probable that the field extends a considerable distance beyond that point. Large flows have also been found at Bow Island. The northern limit has not been defined as drilling has only been done close to the city. Medicine Hat gas is found at three different depths. The first is at 125 feet and this gas is damp; the second is at 625 feet and this gas also carries a little moisture, but at one time, was used as source of supply. The pressure of this gas is about 250 lbs. per square inch. The city is now supplied with gas from a depth of 950 feet to 1050 feet, and the wells drilled to this strata have a capacity from 2,500,000 cubic feet to 4,000,000 cubic feet per 24 hours. The rock pressure at this depth is about 585 lbs per square inch, and the gas contains no moisture. The cost of drilling one of these wells is about $10,000. Medicine Hat has been using gas for about 14 years.

The analysis of the gas is as follows:—

Methane	99.49%
Hydrogen	.51%
Oxygen	a trace.
B.T.U. per cubic foot	1100

During the year 1913, the domestic consumption amounted to 750,000,000 cubic feet, while the industrial consumption was about 900,000,000 cubic feet extra. The gas is sold for domestic purposes at the rate of 13½c per 1,000 cubic feet and for industrial consumption at 5c per 1,000 cubic feet.

For distribution throughout the city, the gas is first passed through a high pressure and then through a low pressure regulating station. The gas, on coming from the wells, passes through a high pressure regulating station where the pressure is reduced to about 40 lbs., and mains run through the city carrying gas at this pressure on which are located low pressure regulating stations which again reduce the pressure to about 6 ozs. at which pressure it is distributed through low pressure mains to the consumer. For manufacturers, regulators are installed to give whatever pressure may be required for the particular purposes to which it is applied.

3. *THE MONARCH ZINC MINE, FIELD, B.C.*

Correspondence was laid before the Commission with respect to this mine, showing that it contained a large amount of zinc ore of fairly high-grade, and that it was very desirable that a zinc smelter of the Belgian type should be erected in some part of Canada for the treatment of this ore.

The following letters were received:—

July 17th, 1915.

Letter from H. H. Stevens, M.P. to Col. D. Carnegie, enclosing the following letter:—

June 18th, 1915.

Letter from W. Gray, Managing Director of the Great Western Mines Development Company, Limited, to H. H. Stevens giving the conditions of the Monarch Mine. He states there are 200 tons of zinc concentrates ready for shipment and 20,000 tons of 24% zinc ore awaiting treatment. No market can be found for this. It was considered that the Government should aid in the establishment of a zinc smeltery in Canada. (This letter is appended in full.)

June 18th, 1915.

Letter from N. W. Emmens, General Superintendent of Monarch Mine to W. Gray with regard to the mine. He states the mine contains a large body of ore assaying 32% to 51.6% of zinc, but so high in lime that it cannot be shipped without concentration. The concentrates produced contain 46.7% zinc, 4.5% lead, 4.16% lime. They could produce regularly 300 tons of these concentrates per month with a minimum content of 45% of zinc. Mentions Medicine Hat as a site for a zinc smelter. Asks for Government aid in starting this by embargo on exportation of ores, bonus on zinc, or contract for output at fixed price. Suggests importing Belgian refugee workmen. Gives price paid for Canadian ore by American smelters, and freight and duty charges involved in shipping to the States.

July 14th, 1915.

Letter from N. W. Emmens to R. F. Green, Victoria, B.C., refers to the treatment of zinc ores in Canada. Oklahoma zinc smelters contemplate immediate extension of smelting capacity.

Wish to secure ores in British Columbia making permanent contract. Board of Trade in Medicine Hat would aid in establishment of a smelter at that point. Exportation of ores to Great Britain unprofitable.

June 3rd, 1915.

Letter from W. H. MacDonald, of Medicine Hat, to Col. David Carnegie referring to possibility of locating zinc smelter at Medicine Hat. Electric power supplied by city at one cent per k.w.h., and gas at one cent per 1,000 cubic feet. Refers to Emmens' letter.

May 18th, 1915.

Letter from N.W. Emmens to Medicine Hat Board of Trade, advocates the production of zinc in Canada by the ordinary ore Belgian process. States that 10,000 tons per annum of 45% zinc ore is the minimum requirement of such a plant. The Monarch Mine could supply 4,000 tons per annum. Suggests Medicine Hat as a favourable location. Cost of plant and working capital would be $200,000. Speaks of marketing the zinc in Canada and Great Britain.

W. Gray, Managing Director,
Great Western Mines Development Company, Ltd.,
1417 Dominion Building,
Vancouver, B.C., 18th June, 1915.

H. H. Stevens, Esq., M.P.,
City.

Dear Mr. Stevens:—

Referring to my telephone conversation with you the other day, regarding zinc, I beg to give you the following particulars:—

There are on the siding at Field, B.C., ready for shipment, 200 tons zinc concentrates for which we have been unable to find a market, as the smelters in the United States are smelting to capacity.

There has been mined 20,000 tons of zinc ore assaying 24%, which is lying on the ground ready for treatment in the plant which stands on the property.

The plant alone cost $55,000 and an equal amount has been spent in getting the ore out.

As you are aware there is no zinc smelter in Canada, although a commission was appointed to investigate zinc ores in British Columbia by the Dominion Government some years ago. I need hardly say that the want of a smelter is a matter very gravely affecting the zinc ore industry of British Columbia generally, the American smelters naturally favouring their own mines before those of a foreign country.

Some weeks ago Col. Carnegie, when in Vancouver made the statement that the Imperial Government was somewhat concerned over the fact that no

metallic zinc was produced in Canada, and in event of the United States becoming involved in the war, it might seriously hamper the supply of metallic zinc so necessary to the Allies.

Statistics show that over $1,000,000 of metallic zinc, and nearly $1,500,000 of galvanised iron is imported by Canada, the bulk of which comes from the United States.

I believe that if the Dominion Government were satisfied that a zinc smeltery would be established for the treatment of Canadian ores, that they would be willing to subsidize such a works for the first few years, either by payment of a bounty on all zinc produced from Canadian ores by such works, or by the establishment of an import duty on galvanized iron and other zinc manufactures.

Surely after expending money and energy to develop the province there must be some way of disposing of the product.

Trusting to have your assistance in this matter,

I am, yours very sincerely,

WM. GRAY,

Managing Director.

SECTION IX. EASTERN CANADA

1. *LETTER OF MAY 17th, 1915, FROM MR. J. E. McALLISTER, 15 KING ST. WEST, TORONTO, TO COL. DAVID CARNEGIE, GIVING ANSWERS TO A NUMBER OF QUESTIONS ON THE REFINING OF COPPER IN CANADA.*

Mr. McAllister states that he was for many years engaged in mining and smelting. He was for a time general manager of one of the large copper companies of British Columbia,* and the refining of blister copper was frequently under his consideration, to supplement operations involving the mining and smelting of half a million tons of ore per annum to yield 18 lbs. of copper per ton.

The questions and answers follow:—

1}
2} Q. Have you considered the question of refining blister copper in Canada, and what are your conclusions?
Do you favour refining in Canada? If so, why? If not, why not?

A. The total Canadian production of copper in 1914 amounted to 37,500 tons, of which 14,500 tons was in combination with nickel, leaving a balance of 23,000 tons. This entire balance, providing it was turned out in the form of blister copper, would be hardly sufficient to commercially comprise the output of an electrolytic copper refinery. This operation has been carried to an exceedingly high state of efficiency in several refineries near New York, and a Canadian plant would necessarily have to compete with these, there being no advantage in freight, as the blister copper shipped to the American refineries is 99% pure, and in any event, the railroads usually grant rates on metals under the term "refined in transit", by which only the freight on the rejected impurities is lost. I have always favoured refining in Canada, and the present situation created by the European war is sufficient evidence of the grave importance

*British Columbia Copper Company at Greenwood. B.C.

of producing refined electrolytic copper in the British Empire, but commercially it could not be accomplished in competition with the above mentioned refineries of the United States, for the reason that the output would be too small to form an adequate divisor in figuring the refining cost per pound, even if the other conditions mentioned in the answer to question 3, were favourable.

3\. Q. What location or locations would, in your opinion, be the most advantageous for a copper refinery and why?

A. Regarding location. The first consideration would be cheap electric energy, next temperate climate, then cheap fuel and supplies, and finally satisfactory labour conditions. These requirements would probably best be met in the aggregate at Niagara Falls, but the advantage of a refinery located upon tidewater, is obvious, providing the other conditions could be procured.

4\. Q. What would it cost to refine copper at the point you consider is the best location for a refinery, and how would these costs be distributed among the items:—Interest on investment? Overhead? Power? Fuel? Labour? Marketing?

A. The answer to this would involve an investigation of some magnitude. With regard to cost, it may be noted that the writer has in the past contracted in New Jersey for the refining of blister copper containing gold and silver, at a total charge of $13.00 per ton, with all the metals as determined by assay being paid for. There was perhaps a small indirect profit to the refinery from extracting more gold than could be determined by assay, which would be somewhat offset by a loss in silver, so that the profit in this contract practically consist in the difference between the actual cost of refining (say from $8.00 to $10.00 per ton) and the charge of $13.00.

5\. Q. Would you favour an amalgamation of the principal copper producers in British Columbia to control one central refining plant?

A. The amalgamation of the principal copper producers of Canada, as distinct from those producing copper and

nickel combined would be essential to the establishment of a refining plant.

6. A. What production of blister copper per annum would be needed to support a copper refinery on a commercial basis?

A. A minimum output of 25,000 to 30,000 tons of refined copper per annum would be required to support a refinery on a commercial basis.

7. Q. In what way do you think that the Government could best assist in the establishment of a refinery?

A. The Government could assist in establishing a Canadian refinery by subsidizing the same until its output was sufficiently large to admit of its operating cost reaching a level which would compare with the highly efficient operations of the modern plants in the neighbourhood of New York City, but at present there are not copper mines of sufficient size in Canada to provide such an output. In this connection, however, the British American Nickel Corporation has submitted a plan to the Dominion Government which will insure the requirements of the British Empire for refined nickel being produced in Canada, and incidental to this, an appreciable tonnage of refined electrolytic copper would be turned out at the same time. The plan, which is at present before the Government, is as follows:— The corporation has expended to date $5,750,000 of which $3,000,000 is in bonds bearing interest at 5½%. It desires to expend a further $2,000,000 which expenditure would complete works for the first installation to produce 3,000 tons of refined nickel and 1,500 tons of refined copper per annum, both being electrolytic. Ultimately it proposes to increase this production to 10,000 tons of nickel and 5,000 tons of copper per annum. The corporation proposes that the Dominion Government advance this $2,000,000, for which the Government would receive first mortgage bonds secured by all the property of the company, the same ranking as a senior security with the present bond issue of $3,000,000. The corporation would in addition, deposit with the Government as collateral security $5,500,000 of its

capital stock. It has already opened up an ore supply of 11,000,000 tons, sufficient to maintain its operations for many years to come, and its entire plan of operation has been thoroughly investigated and proved by technical and commercial experts.

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2. *OPINIONS OF EASTERN MANUFACTURERS WITH REGARD TO COPPER REFINING IN CANADA.*

A letter was written, about the 4th of May, 1915, to a number of Eastern Manufacturers in regard to the possibility of refining copper in Canada. The following was the form of letter employed:—

Shell Committee,
Drummond Building,
Montreal, May 4th, 1915.

Gentlemen:—

On behalf of the Commission appointed by the Minister of Militia to enquire into the feasibility of refining copper in Canada, with the object of stimulating the mining industry and also the manufacture of copper, which it is hoped may be refined in Canada, I shall be pleased if you will inform me to what extent you use refined copper imported to Canada and in what form.

I shall be glad also, to have your opinion regarding any commercial advantage likely to be derived by the manufacturers, from the use of copper refined in Canada, in preference to the use of imported copper.

Any remarks you may make on this subject, which will benefit Canadian Industries, will be much appreciated.

I am,
Yours very truly,
D. CARNEGIE,
Chairman of Commission.

The following replies were received:—

The Northern Electric Company, Montreal.

Uses 1,000,000 lbs. of copper wire rods per month. Most of the copper used in Canada is in the form of rods, sheets and tubes. There has not been enough demand to warrant the erection of rolling or tube mills in Canada, and until that is done the

refining of copper in Canada would be of little use. Some refined copper is used in the form of casting ingots.

Canadian General Electric Company, and
Canadian Allis Chalmers, Limited, Montreal.

The company uses 800 tons of refined copper annually, the greater part in the form of wire rods, 100 tons as finished bars and sheets. Mr. Nichols does not see any commercial advantage to his company from the refining of copper in Canada.

Canada Wire & Cable Company, Toronto.

Import 3,000,000 to 3,500,000 lbs. of copper per annum in the form of rods. See no commercial advantage to themselves in having copper refined in Canada, but think this should be done, and that it would ultimately benefit Canadian industry.

Tallman Brass & Metal Company, Hamilton.

They use 1,000,000 lbs of copper per year in their foundry. Are favourable to refining copper in Canada.

James Morrison, Brass Manufacturing Company, Toronto

Use 150 tons of copper per year for brass making. Consider strongly that copper should be refined in Canada and occasionally find it a handicap to have to purchase copper from the United States.

Jenkins Bros. Limited, Montreal.

Import about 800,000 lbs of ingot brass per annum. Think a copper refinery in Canada would be of advantage to Canadian manufacturers and stimulate Canadian mining industry. This would place Canadian manufacturers on an equal footing with those in the States providing that the transportation charges do not offset the saving of duty and freight from the United States.

Eugene F. Phillips Electrical Works, Montreal.

Use 12,000,000 lbs. of copper per annum in the form of rods. Consider that a Canadian refinery would affect them adversely as there is not business enough to supply a rolling mill in Canada. They use rods of various sizes and have to get these from different mills.

Canadian Bronze, Limited, Montreal.

Consider local consumption is not sufficient to warrant the establishment of a refinery, and that a small refinery could not compete for foreign business with the larger ones in the States. Such a refinery would be protected by the $7\frac{1}{2}\%$ War Duty, but the local consumption would not provide for the output. Retaliation by the States, which is to be expected, would cause financial loss to the Canadian copper manufacturers. The establishment of a refinery, under a protective tariff, would not help Canadian trade, but would add greatly to the cost and restrict the scope of the copper and brass industry.

The Grand Trunk Railway System, Montreal.

Use 350 tons of copper per annum for making brass, etc. Also unspecified amount of manufactured copper such as wire, sheet, etc. Consider it doubtful whether any advantage would be derived by refining copper in Canada in view of the fact that fuel and skilled labour are more expensive in this country than in the States.

The Garth Company, Montreal.

Use about 200 tons of ingot copper per annum. Ingot copper costs 1.5 to 1.75 cents per lb. more than in New York. If a refinery company was started, receiving Government protection, the price of copper to the Canadian consumer would be even higher. Refers to a small mill in Toronto receiving a Government protection of 10%, but which cannot make satisfactory output of sheet or rod brass.

Empire Manufacturing Company, London, Ont.

Use 100 tons of copper per annum, mostly in the form of scrap from other countries. Also 250 tons of scrap brass. Would favour the establishment of a copper refinery in Canada.

Canadian Vickers Limited, Montreal.

Cannot give any information with regard to consumption of copper. At present copper in bar or ingot is imported free into Canada. If a refinery were started there would no doubt be a protective duty which would not be desired by the manufacturers.

The Russell Motor Car Company, Toronto.

Use 25 to 50 tons of refined copper pig per annum. Refers to

$7\frac{1}{2}\%$ duty on copper and believes that if a copper refinery were established it would lead to the establishment of an industry for the manufacture of manganese bronze, etc.

Montreal Locomotive Works, Limited.

Import copper pipe to the value of $12,000 to $15,000 per year and $700 to $800 of copper rivets.

The Canadian Pacific Railway Co., Montreal.

Used 28,000 lbs. of brass and copper rods and sheets during 1914. All their brass castings are manufactured by Canadian firms.

The Intercolonial Railway Co., Moncton, N.B.

Use 50 tons of refined copper per year.

The Canadian Westinghouse Co., Ltd., Hamilton.

Use large quantities of copper in ingots, sheets, bars, wire, tubes and other shapes. If these were procurable in Canada would give their preference to the Canadian product. Consider that the refining of copper in Canada would be of benefit to Canadian users.

The Robt. Mitchell Co., Montreal.

Use 60 tons per annum of ingot copper.

Canadian Locomotive Company, Kingston.

Use 3,000 lbs. of ingot copper per month. Do not see any advantage as regards cost if copper is refined in Canada. Copper refining could only be developed by means of Government by way of bounties or protective tariff.

The letters show that 30,000,000 lbs. of copper is imported annually by the above named manufacturers. This copper is largely in the form of wire rods, tubes, sheets, etc., but also as ingot copper for casting purposes and as ingot brass. Many of the letters of the manufacturers consider that it would be to the general interest of Canadian industry that copper should be refined in Canada, but fear is expressed that copper refining would need Government protection, and that this would raise the price to the manufacturer of the finished copper. It appears also to be an essential part of such a scheme that the refined copper should

be rolled in Canada into wires, rods, sheets, etc., and this would involve the establishment of a considerable industry for this purpose. There will be no chance of selling any part of the output of such refinery or rolling mills to the United States. They would have to depend on Canada and perhaps Europe for a market.

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3. *OPINIONS OF EASTERN MANUFACTURERS WITH REGARD TO ZINC SMELTING IN CANADA.*

The following letter was addressed to a number of firms who are using spelter.

Shell Committee,
Drummond Building,
Montreal, May 4th, 1915.

Gentlemen:—

On behalf of the Commission appointed by the Minister of Militia to enquire into the feasibility of producing metallic zinc in Canada, with the object of stimulating the mining industry and also the manufacture of zinc products from zinc produced in Canada, I shall be pleased if you will inform me to what extent you use zinc imported to Canada, and whether you see any commercial advantage likely to be derived by the Dominion, from the use of zinc produced in Canada, in preference to the use of imported zinc.

Any remarks you may make on this subject which will benefit Canadian industries, will be much appreciated.

I am.

Yours very truly,

D. CARNEGIE,

Chairman of Commission.

The following replies were received:—

Page Hersey Iron Tube and Lead Co., Ltd., Toronto.

Use zinc spelter of a fair grade containing 98% to 99% zinc for galvanizing. Consumption annually 1500 tons. Consider it an advantage to have British Columbia ores smelted in Canada. Refer to the Frank Zinc Smelter stating that this

was discontinued owing to lack of tariff support. Do not expect any commercial advantage to themselves from production of zinc in Canada and expect that the metal would cost them more than at present.

Thos. Davidson Manufacturing Co., Ltd., Montreal.

Use about 500 tons of zinc for galvanizing and 10 tons of sheet zinc. Consider there would be great commercial advantage in having zinc smelted in Canada. American smelters are in the hands of a group, who are mostly Germans, and the price has advanced about 300%.

McClary Manufacturing Company, Montreal.

Use about 150 tons of zinc spelter and 50 tons of sheet zinc imported from the United States and Belgium. Would be pleased to pay a slightly higher price if this could be produced in Canada.

SECTION X. REPORT ON COPPER REFINING.

REPORT ON THE POSSIBILITY OF PRODUCING REFINED COPPER IN CANADA.

With an Appendix on Statistics for Canada of Copper and Brass

By Alfred W. G. Wilson, to Honorary Colonel David Carnegie, Ordnance Adviser to the Shell Committee, Ottawa, July 17th, 1915.

LETTER OF TRANSMITTAL.

Honorary Colonel David Carnegie, Esq., M.I.C.E.,
Ordnance Adviser to the Shell Committee, Ottawa.

Sir:—

I have the honour to transmit herewith a report on the possibility of producing refined copper in Canada, together with certain appendices on the following subjects:—

1. Zinc resources of Canada.

2. Statistics for Canada of copper, zinc and brass.

3. Special memorandum on the securing of emergency supplies of copper and zinc from Canadian sources.

This report supersedes all previous memoranda on these subjects that have been addressed to you by the undersigned.

I have the honour to be, Sir,
Your most obedient servant,
ALFRED W. G. WILSON.

Mines Branch, Department of Mines,
Ottawa, Canada,
July 17th, 1915.

1. *COPPER RESOURCES OF CANADA.*

PRODUCTION OF COPPER ORES.

Native copper occurs in Canada in a number of different localities, but in no place within reach of existing lines of transport has exploration work disclosed concentrations of the metal in sufficient quantity to render it practical to operate these deposits commercially by present methods, the copper content of the rock being usually less than one per cent.

Minerals containing copper as an essential constituent occur in many places throughout Canada. Those commercially important are the sulphides; carbonates and oxides also occur, usually in association with sulphide deposits, but they are relatively of minor importance. The two sulphides, chalcopyrite and bornite, both of which also contain iron, are the most important; locally chalcocite, the pure sulphide, is also occasionally found. At the present time copper sulphide ores are being mined successfully in the following districts in Canada:—

1. *Quebec.*—Eastern townships in the vicinity of Sherbrooke; the annual production varies, it has been increasing in the last few years and may be taken as about 4,000,000 lbs. per annum. The Quebec ores are mined for their contained sulphur and are marketed chiefly in the eastern United States; the copper recovered is in the nature of a by-product, and is recovered in United States plants after the available sulphur has been extracted.
2. *Ontario.*—Sudbury district. The annual production has been increasing in recent years. In 1914 it was about 29,000,000 lbs. This copper occurs in association with nickel in the pyrrhotite ores of this district. Locally the ores are smelted and treated in basic converters producing a matte which contains 80-82% of the combined metals, the balance consisting of iron and sulphur and very small quantities of other metals. The matte containing the two metals is exported to the United States and to England to refineries where the two important constituent metals, and certain included by-products are recovered separately.
3. *British Columbia.*—There are three principal producing districts:

(*a*) *Kootenays.*—Including Rossland with a production of 3,779,830 lbs. in 1914, and Nelson with a production of 586,764 lbs. in 1914. These are both tributary to the smelter of the Consolidated Mining and Smelting Company of Canada (C.P.R.), at Trail. The Rossland ores are essentially gold ores; they, however, contain a small amount of copper in the form of a sulphide, not much over one half of one per cent., but sufficient to make it feasible to recover the gold by the methods of the copper smelter.

(*b*) *Boundary.*—The production in 1914 was about 16,400,000 lbs. Formerly there were two smelters operating in this district, that at Grand Forks, belonging to the Granby Consolidated Mining Smelting and Power Company, and that near Greenwood belonging to the British Columbia Copper Company. The mines and smelter belonging to this latter company were closed in August, 1914, at the beginning of the war.* The mines and smelter of the former company were closed, and afterwards re-opened. It appears probable that the production of this district will gradually decline, unless new deposits are discovered and opened up.

(*c*) *Coast Districts.*—The production of the British Columbia coast districts in 1914 was about 24,000,000 lbs. At present there are three principal producing centres:—

I. *Britannia Mines.*—On Howe Sound, producing ores and concentrates which are shipped to Tacoma, Washington. The normal production is 15-18 million pounds of copper per annum, but it fell below that figure in 1914. When work now under way is completed, production will be in the neighbourhood of 25,000,000 lbs. per annum.

II. *Anyox.*—On the Portland canal about 110 miles north of Prince Rupert, at which is located a smelter, present capacity 2,500 tons of ore per day—to be increased to 4,000 tons—produces blister copper which is shipped to Laurel Hill, New Jersey, for refining—owned by the Granby Consolidated

*They were re-opened in 1915.

Mining, Smelting and Power Company. A statement as to the present production is not available, but when the capacity of the plant has been increased to the daily tonnage indicated the annual production should be in the neighbourhood of 45,000,000 lbs. of copper.

III. *Texada Island.*—Has produced a small amount of copper during the last few years, chiefly from the Marble Bay mine. In 1914 the production was 771,000 lbs., which may be considered to be about two thirds normal.

VI. *Other Localities.*—A small quantity of copper has been secured, from time to time, from a number of other localities along the coast of British Columbia or from some of the islands adjacent to that coast. Prospecting, exploration, or development work is now in progress in a number of localities and it is probable that new and important discoveries will be made from time to time. One new property east of Prince Rupert and near the main line of the Grand Trunk Pacific Railway has recently made a shipment of ore to Anyox.

(*d*) *Similkameen.*—Extensive explorations in the Similkameen, not far from Princeton, have been in progress during the last four years. They have shown the existence of large bodies of low grade ores. It is probable that this district will become a producer of copper within the next two years.

4. *Yukon.*—Only one copper mine of importance is operating in Yukon—the Pueblo near Whitehorse. The production from this mine during the last three years has been at the rate of about 1,700,000 lbs. per annum. How much ore there is in reserve it is not possible to state. At present the ore is all shipped to Tacoma, Washington, for treatment.

Summarizing the above statements it will be noted that the annual production of copper from existing mines in Canada is in the neighbourhood of 80,000,000 lbs. a little more than one third of this being produced in eastern Canada, and a little less

than two thirds in British Columbia. (The total copper recovered from ore produced in Canada in 1914 is estimated by Mr. McLeish, Chief Statistician of the Mines Branch, at 75,738,386 lbs. In 1913 it was 76,976,925 lbs.).

ORE RESERVES.

With reference to the known ore reserves, upon which future production must depend, there is little accurate information available. It has not been the custom of the operating companies to make public much information with respect to these reserves, even when they themselves possess it, The larger companies all carry exploration and development work in advance of mining and in the majority of cases know that they are assured of ample reserves to keep their present plants in operation for some years to come.

In Quebec the reserves have not been made public, but they are known to be more than enough to insure production at the present rate for more than two years. In the Sudbury region of Ontario the known reserves are variously stated to be in excess of 100,000,000 tons of ore carrying about 2% copper besides nickel. The operating companies have not made public any official figures with respect to these reserves.

British Columbia is at present the principal copper-producing province of Canada, copper-bearing minerals being found in numerous localities in various parts of the province. The known occurrences are too numerous to be considered individually. The principal producing districts have already been enumerated. Some of the operating companies publish statements of their ore reserves, others do not, and as a consequence it is not possible to make a definite statement as to the tonnage of ore known to be available. A rough estimate, based in part on the published information supplied by certain operating companies, and in part upon rough, and therefore possibly inaccurate, estimates of the ore reserves of other companies, indicates that the known ore deposits of this province contain in excess of 500,000 tons of recoverable copper equal to twenty years' supply at the present rate of production. In addition to these known ore deposits, which are now being exploited, there is every reason to believe that other equally important discoveries will be made in the future.

PRESENT METHODS OF TREATMENT.

1. *Quebec* ores are nearly all exported to the United States, where the sulphur is first utilized for the manufacture of sulphuric acid and the copper contents of the ores are afterwards recovered at other works.

2. *Ontario* ores are roasted in open heaps, or in small part in mechanical furnaces, to drive off a portion of the sulphur. They are then treated in blast furnaces, or reverberatories, to produce a low grade matte containing the nickel and copper. This matte is further concentrated in basic lined converters until it contains 77-82% of the combined metals. In this form about 15% of the Ontario production is shipped to Wales, and the balance to the United States for further treatment. A portion of that sent to the United States is again treated to produce the alloy called monel metal, without the separation of the copper from the nickel. The balance of that sent to the United States and all of that sent to Wales is refined by special processes, the copper and the nickel being recovered separately.

3. *British Columbia* ores are in part sold directly to United States purchasers, and in part given a partial treatment before being shipped to the United States. The smelter at Trail produces a matte containing approximately 42% copper and a considerable amount of precious metals. This matte is at present being shipped to Tacoma, Washington, for final treatment and refining. I understand that it is the intention of the Consolidated Company to install converters at Trail and to produce blister copper. This blister copper will contain an unusual amount of the precious metals, owing to the nature of the Rossland ores, and it will probably be necessary to refine it on the spot.

The ores from the Boundary district were treated at Grand Forks and at Greenwood, both plants using blast furnaces in which a low grade matte was produced, and afterwards treating this matte in converters to produce blister copper. The blister copper, which contains 96-98% copper, was shipped to United States points for refining. The plant at Greenwood is at present idle.*

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*Since re-opened.

The ores mined at Anyox, north of Prince Rupert, are treated in blast furnaces, the resultant matte being blown to blister copper in basic converters. The blister copper is shipped to Laurel Hill, New Jersey, for refining. A small amount of custom ores from outlying points can also be treated at Anyox.

The ores mined at Britannia are concentrated in a special plant at Britannia Beach, and are then shipped to the smelter at Tacoma for final treatment. Ores from the Marble Bay mine on Texada Island, and those from the Pueblo mine in Yukon are also shipped directly to Tacoma for treatment.

4. *Summary.*—The foregoing paragraphs may be summarized by stating that all the copper obtained from ores mined in Canada is recovered in refineries located outside Canada, and chiefly in the United States. About ninety per cent. of the copper produced in Eastern Canada is converted into a high-grade matte before shipment; about sixty-six per cent. of the copper produced in British Columbia is converted into blister copper before shipment, and in all about twenty-five per cent. of the copper ores mined in Canada is shipped directly to United States points for metallurgical treatment.

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2. *REFINING OF COPPER IN CANADA.*

GENERAL STATEMENTS.

1. *Present Conditions.*—Canada refines no copper at the present time. About one-half of her annual output of copper is treated in blast furnaces and afterwards in converters, and is exported in the form of blister, containing usually 95-98% copper, a few ounces of gold and silver per ton, and some impurities; about one-third of her output is exported in the form of matte, either high grade and associated with nickel, as from the Sudbury region, or of relatively lower grade but containing much gold and silver, as from Trail. The remainder of Canada's copper production is exported to foreign smelters for treatment as ore, some of

it being concentrates and some of it untreated. The reasons why this condition exists are various and complicated. In brief it may be stated that the copper producing industry in Canada has been of slow growth, and has been prosecuted largely by foreign capital which already possessed established business connections outside Canada. In the early days it was much cheaper to arrange for the final treatment of the Canadian product in established foreign plants; it was easier, and there were fewer capital risks.

At the present time over 80% of the refinery capacity of North America is located within fifty miles of New York city and is therefore in the immediate vicinity of the largest American markets and shipping ports. An important factor in determining the location of these refineries has undoubtedly been the enormous saving that has been effected by reducing to a minimum the time that capital is locked up in the refined copper in transit. Another factor determining their location in this district was the possibility of securing relatively cheap power, cheap labour, and cheap supplies of all kinds, including appliances and machinery. Moreover the freights on the raw materials and supplies would be lower than on a finished product and on supplies hauled a long distance. All the conditions which brought this about may be summarized by stating that refining could be done more cheaply and conveniently in the district where the large refineries are now located than elsewhere. Once these large refineries were established in their present location it has become increasingly difficult for new organizations to compete against them and break into the market, unless the circumstances are exceptional. Moreover the capital interested in the established refineries is also the preponderating interest, directly or indirectly, in the Canadian copper production. Under these circumstances it should not be a matter of surprise that Canada's copper is not refined at home, nor can it be expected that the conditions will be changed unless existing circumstances, altered by natural conditions or by design, become such that it will be more profitable to refine Canadian ores in Canada instead of in a foreign country.

2. *Canadian production available for a refinery.*—The nickel-copper mattes produced in the Sudbury district, Ontario, present a special problem in refining, involving the recovery not only of the copper, but also of the nickel, and therefore do not need to be considered here. That portion of Canada's copper which can tentatively be considered as available for refining in Canada is the British Columbia production.

A survey of the field shows that the British Columbia copper production may be considered as tributary to two principal localities. The production of Rossland and the Boundary country is all confined to the south-eastern part of the province, and geographically would naturally be tributary either to Trail or to a plant located elsewhere in one of the Kootenays. The balance of British Columbia production comes from points on the Pacific coast and therefore may be considered as tributary to certain points on tidewater.

Again, considering the present development of the various known copper-producing mines, we find that the mines of the Boundary district have probably reached their maximum production and are now on the decline. The Motherlode, the largest mine tributary to the smelter at Greenwood, is estimated to contain about two years' supply of ore; the mines at Phoenix, tributary to the smelter at Grand Forks, are credited with containing enough ore to keep the smelter working to capacity for only a few years more. The Rossland mines are stated never to have been in better condition, but the total copper content of these ores is comparatively small. Other less well-known mines produce ore from time to time, but their operation has been more or less spasmodic and they cannot be relied on to produce a large tonnage or to produce continuously for any length of time. Undoubtedly new ore bodies will also be discovered, prolonging the lives of existing plants in this section of the province, but the ore supplies immediately in view are such that it is extremely improbable that the annual production of copper from the Kootenays will materially increase in the near future.

On the coast we find that extensive development work has been in progress for the last three or four years, showing the existence of large ore reserves, particularly at Britannia and Anyox. On the strength of this development, preparations have been made at both localities for handling greatly increased outputs of ore. There are, in addition, a number of other smaller properties from which additional ore supplies may be expected, and in general it may be stated that the districts tributary to the coast appear to be the most promising in regard to future development.

In 1914 the interior districts produced approximately 21,000,000 lbs. of copper, while the districts tributary to the coast produced about 24,000,000 lbs. It is not probable that the annual production of the interior, within the next few years, will much exceed this amount; the coast districts on the other hand give promise of at least doubling the output within the next two years.

A new district in the vicinity of Princeton, in south-central British Columbia, is now undergoing exploration and development. The development work at present recorded already shows the occurrence of a large tonnage of copper ore and more may be expected. If it is decided to treat these ores at Greenwood the blister copper produced would greatly increase the production of the interior district. On the other hand, if it is decided to treat these ores at some point near the mines, this production would naturally be tributary to a coast refinery, particularly when the direct railroad to the coast, now under construction, is completed. The establishment of a refinery in British Columbia and its location would have an important bearing in determining the location of the smelting and converting plant for the preliminary treatment of these ores from the Similkameen, assuming that other conditions are satisfied.

If the establishment of a refinery were dependent only on the assurance that an adequate supply of blister copper can be produced, it may safely be stated that there is enough ore in sight to supply the copper necessary to keep a plant of at least 50 tons daily capacity (36,500,000 lbs. per annum) in operation for an indeterminate number of years,

a period of time, however, which would be longer than the normal life of the plant. In reaching any conclusion as to the probable commercial feasibility of such a refinery, there are a number of collateral conditions that must be considered and weighed and there are numerous conflicting interests which must be appraised and adjusted. These conditions are set forth in the succeeding sections of this report.

OPPOSING CONDITIONS.

1. *Present Ownership.*—The only large Canadian-controlled corporation now engaged in mining and smelting copper ores in British Columbia, is the Consolidated Mining and Smelting Company of Canada, with smeltery at Trail, and mines at Rossland and elsewhere—usually referred to in the west as the C.P.R. interests, because the Canadian Pacific Railway is supposed to hold a controlling interest in the organization. All the other important producers of copper or copper ores are controlled by United States capital. Stating the same fact in another way, it is to be noted that only about 10% of the copper production of British Columbia is home controlled, the balance, about 90%, is foreign controlled. When the anticipated increase in production from coast points takes place, this balance will approximate 95% of the total.

2. *Existing Contracts.*—Nearly all the companies which are mining copper ore in British Columbia and all the smelters which are producing blister copper have contracted for the disposal of their output. These contracts usually run about five years, and existing contracts have at least two years yet to run.

3. *Smelter Capacity.*—The smelter capacity at present available on the coast is not sufficient to treat all the ores now produced there. It is reported that the smelter at Anyox is to be enlarged to a capacity of about 4,000 tons of ore per day (the present capacity is 2,500 tons), but this will provide for the output from Anyox only. Another smelter specially equipped to treat concentrates as well as ordinary ores of copper, will be required to treat the ores and

concentrates from Britannia and such other ores as may be available from time to time. The capacity of this smelter should be at least 500 tons per day, and provision should be made to double this capacity, if necessary. It is possible that the company now operating the Britannia mine would consider the erection of a smelter to treat their own ores and to produce blister copper. The smelter at Ladysmith, now idle, is capable of treating some of the ores, but not so economically as a more modern plant specially designed for the purpose. It would probably seriously handicap the development of a coast refinery to attempt to adapt the Laydsmith smelter as it now stands to the needs of such refinery.

4. *Marketing.*—One of the most difficult problems confronting a Canadian refinery would be the marketing of its products. Hitherto Canada's total consumption of copper has been about 20,000 tons per annum, slightly less than half the production of British Columbia. The greater part of this copper is imported into Canada in manufactured forms, particularly wire, rods, and sheets. The surplus production from a Canadian refinery would have to be sold in the open market. If it is produced under natural conditions and at reasonable cost, there appears to be no reason why it could not successfully compete with copper produced elsewhere. The competition of the large purchasers in the United States and in South America would have to be faced, and even possible price-cutting. On the other hand, there is a possibility that the cheapness of production and the geographic location of the refinery might give certain advantages which it would be very difficult to offset.

Under existing conditions eastern manufacturers who require refined copper can, or could before the war, often obtain deliveries within a week of the placing of the order. Eastern refineries often had their orders booked in advance of the refining, and as a consequence there was little capital locked up in the copper in transit.

A refinery in western Canada, operating under existing conditions, would have the following factors to contend with:—

I. Long haul to eastern market on a refined product, and therefore at a higher rate.

II. An unusually long interval must elapse between the receipt of orders and the time of delivery—resulting in proportionally larger interest losses on copper in transit.

III. Variety of forms in which refined copper must be delivered to suit the requirements of individual consumers of small lots means an expensive plant for a small output.

IV. Canadian demand is chiefly for copper in manufactured forms. The demand for refined copper in ingots, wire bars, and cakes is very small.

V. Competition of foreign copper, much of which can be laid down in the eastern market more cheaply.

It therefore appears desirable that other markets than that offered by eastern America be considered. Data with respect to the requirements of these markets are not immediately available. It may be pointed out, however, that refined copper from a British Columbia coast point can be laid down in British ports, and in certain continental ports at less cost per pound than from many of the interior United States producers. The Asiatic markets, and the Australian market are also open to a coast refinery, with corresponding low freights. It appears extremely proable that any surplus production from such a refinery could be very easily disposed of in the face of eastern competition.

I am inclined to think that it would be most profitable for a coast refinery to transform its own refined copper into manufactured products such as wire, rods, sheets, bars and tubes. These products could be marketed as easily as the refined copper. There would be a very considerable saving in interest losses on copper in transit and a probable saving in refinery equipment.

5. *Power Problems.*—The principal individual item of expense in the operation of a copper refinery is the cost of power. Hydro-electric power can be produced at a number of points on the coast of British Columbia at a cost of less than $10.00 per h.p. year. The most desirable and convenient power sites appear to have been transferred to private hands, but most of them are neither being utilized

nor developed. The tax which these holding interests are inclined to levy on *bona-fide* industries requiring the power is apt to be almost prohibitive. Before a refinery could be established it will be necessary to arrange to obtain power at a reasonable figure, which should not exceed $10.00 per h. p. year, delivered at the plant. The operating company should own and control its own plant, and there should be sufficient available power in reserve to provide for reasonable expansion and the development of subsidiary industries.

6. *Diversity of Products.*—The nature of the products from the different centres makes certain commercial adjustments difficult but not impossible. The blister copper which will be produced at the Trail smelter will contain an unusual amount of gold, so much so that it will be practically impossible to satisfactorily and safely sample it. For this reason the owners of the Trail smelter will probably hesitate in agreeing to supply their blister to an independently controlled refinery unless special arrangements are made for its separate treatment. Again the production of the Britannia mines, which will be about 25,000,000 lbs. per annum within two years' time, is in the form of ore and concentrates. Several other mines on the coast also produce ore and do not reduce it to matte or blister. As already noted, a smelter would have to be provided especially equipped to treat these products.

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3. *ORGANIZATION OF A REFINERY.*

PRELIMINARY STEPS.

The organization of a copper refining company will require much consideration and some educative work. At present there are four large companies operating in British Columbia, whose interests are more or less conflicting. It is very desirable that as much as possible of the copper which these companies produce be treated in the one plant.

One of the companies, that now operating at Trail, is Canadian-owned and is in the best potential position to start refining, both as regards equipment and technical staff. They now operate

an electrolytic lead refinery, and an electrolytic copper refinery could be established very easily. Moreover this latter could be started and operated successfully on a very small scale, as there would be no increase of present overhead charges, and the necessary capital expenditure need not, at first, be very great. The power cost would be comparatively high, about $20.00 per h.p. year, and the location is not favourable to cheap freights for incoming supplies and outgoing products. A refinery at Trail would naturally receive the blister copper from the smelter at Grand Forks, involving a rail haul of about 88 miles. Any blister produced at Greenwood might also be sent to Trail, the rail haul being 103 miles.

On the other hand, the blister copper that will be produced at Trail contains unusually large amounts of gold, and I am told that experience has shown that it is practically impossible for blister of this character to be sampled satisfactorily. Therefore it is to be expected that while Trail may be willing and ready to undertake the production of refined copper at their own works, and to purchase blister copper from other producers, it is natural to infer that they will not be willing to co-operate in the establishment of a refinery elsewhere, unless they can obtain specially favourable terms for the treatment of their blister, or be guaranteed its separate treatment.

The companies operating at Grand Forks and Greenwood, which points, as already noted, are naturally tributary to Trail, would undoubtedly be willing to contribute their blister to some other point than Trail, the only questions involved being commercial ones.

The two principal producers on the Pacific coast of British Columbia are the Granby Consolidated Mining, Smelting and Power Company, with smelting works and mines located 110 miles north of Prince Rupert, and the Britannia Mining and Smelting Company, with mines near Britannia Beach on Howe Sound, about 30 miles north from Vancouver. If the interest and co-operation of these two corporations can be secured the success of the project would be assured. Without the co-operation of both these producers the amount of copper available would be too small to warrant the establishment of a refinery on the coast. Both companies have existing contracts which will have to be completed before they are free to accept new obligations,

and these contracts have several years to run—Anyox, time unknown, Britannia, two years. Both would probably be willing to enter into new contracts with a Canadian refinery, but strictly on a commercial basis—that is the Canadian refinery must at least give them as favourable terms as they now receive or are offered when renewing contracts.

The Canada Copper Corporation, which now controls the interests of the British Columbia Copper Company, and which has been developing the new deposits in the vicinity of Princeton, B.C., is controlled in the United States. At present they are not producing either ore, matte, or blister. It is probable that the output from the Greenwood smelter is already contracted for, but the output from the new mines is not yet on the market.

LOCATION.

1. *General.*—The following points have been considered in an attempt to reach some conclusion as to the best location for a Canadian copper refinery:—

    (*a*) St. Lawrence River, Quebec.
    (*b*) Sault Ste. Marie, Ontario.
    (*c*) Port Arthur, Ontario.
    (*d*) Trail, British Columbia.
    (*e*) Two Pacific Coast points, British Columbia.

    The following are the principal factors that have been considered in each case:—

    (*a*) Relation to sources of supplies of blister copper.
    (*b*) Relation to probable markets for refined copper.
    (*c*) Relation to sources of materials for construction and maintenance.
    (*d*) Probable freights, inward and outward.
    (*e*) Power costs.
    (*f*) Fuel and other supplies.
    (*g*) Labour costs.
    (*h*) Interest losses on copper in transit.

    My conclusion is that British Columbia offers the best locations for the refining of the copper at present available for treatment. With respect to the location of a refinery on the Pacific Coast as opposed to one at Trail, I consider the coast unquestionably offers the best sites for a commercial refinery.

The coast production will, in a few years' time, be at least ten times that of Trail, apart from the copper which might be sent to Trail from the two interior smelters. These smelters, however, could also contribute to a coast refinery, and therefore their production does not need to be specially considered when weighing the comparative merits of locating at Trail or at a coastal point. Trail would have lower capital and overhead charges to meet than a coastal point, but the power costs, fuel costs, and labour costs would be higher, as would freights on supplies and products.

Almost any coastal point is favourably located with respect to freight rates on raw materials and finished products. and has, moreover, an enormous tributary area with low freight charges. Certain points offer particularly low power costs, and cheap oil fuels are available. Inasmuch as eastern manufacturers in Canada would require not more than half the output of such a refinery, even if they were equipped to handle such a quantity, the balance would have to find another market. The potential possibilities of the British, Asiatic and Australian markets are such that the available surplus could probably be placed in these markets more cheaply from the British Columbia coast than from any other point in Canada.

In brief I consider that marketing conditions alone render it inadvisable to locate a refinery anywhere in eastern Canada for the primary purpose of refining British Columbia copper, and I consider that certain Pacific Coast points would afford the best location.

2. *Selection of a Site.*—Since it is assumed that if a copper refinery is established on the coast it would be operated as a commercial enterprise, the site selected should be chosen only on its merits. Primarily it should be on tide-water, and hydro-electric power should be available. The amount of power should be much in excess of the immediate requirements to allow for expansion and the development of certain related manufacturing industries if these appear desirable. The site, moreover, should be centrally located to facilitate the assembling of the products of the different contributing centres, and should be where climatic conditions are most favourable.

EQUIPMENT REQUIRED.

The capital expenditures mentioned in the following paragraphs must be considered only as approximations. An estimate of the probable cost of a completely-equipped refinery, with its various adjuncts, would require a closer analytical study than is now possible of the numerous and varied factors which have to be taken into consideration.

1. *Power Site.*—A suitable site for the development of hydro-electric power will be required. This should be capable of supplying not less than 5,000 h.p. per day, on 24 hour service. This is much in excess of the power required for a 50-ton refinery plant alone, but scarcely allows for reasonable expansion. There are a number of power sites available where about 20,000 h.p. could be secured and developed at a cost not exceeding $100 per developed h.p. At the start it would not be necessary to develop the whole of such a power. The initial development might be pleased at $150,000, though this figure is possibly too low.

2. *Refinery and Auxiliary Equipment.*—A complete refinery will include the following equipment:—
    1. Office building.
    2. Chemical and assay laboratories.
    3. Physical testing laboratory.
    4. Water supply system.
    5. Power plant.
        - (*a*) Coal bins and equipment (or oil tanks).
        - (*b*) Boiler room and equipment.
        - (*c*) Engine room and equipment.
        - (*d*) Generator room, transformers, motors, switch boards and equipment.
    6. Furnace Building.
        - (*a*) Cranes and charging machines.
        - (*b*) Small water-jacketed blast furnace.
        - (*c*) Anode furnaces.
        - (*d*) Cathode furnaces.
        - (*e*) Casting machines.
        - (*f*) Cast iron and cast copper moulds for anodes, wire bars, ingots, and cakes.
        - (*g*) Moulds for making casting machine moulds.

7. Tank house and equipment.
8. Precious metal refinery and equipment.
9. Copper sulphate plant.
10. Supply storage for furnace department.
11. Copper storage, incoming and outgoing.
12. Sampling shop and drills.
13. Scale house.
14. Repair shops.
    (*a*) Forge and blacksmith shop.
    (*b*) Foundry.
    (*c*) Boiler shop.
    (*d*) Machine shop.
    (*e*) Carpenter shop.
    (*f*) Paint shop.
15. Shop supply storage.
16. Yard, tracks, haulage motors, cars, trucks, and other yard equipment.

The cost of a refinery capable of producing about 50 tons of copper per day would be about $600,000, or approximately $33.00 per daily ton of refined copper. If a smeltery is established in connection with the above plant, the small blast furnace mentioned above would not be required.

1. *Smeltery.*—If a smelter is established to treat the tonnage of ore for which there is no present provision, the additional equipment needed will depend upon the character of the ores available and their quantity. One or more reverberatory furnaces, and one or more basic lined converters will be required. It is also possible that a blast furnace would be needed, though this is not essential. The offices, laboratories, shops, and storage warehouses provided for the refinery would also serve for the smeltery, except that they would have to be made slightly larger; the additional cost of a smeltery may be placed at about $750,000.

4. *Docks and Equipment.*—Docks capable of affording wharfage to at least two vessels, of about 7,000 tons capacity, would be required. They should be equipped for unloading ores, concentrates, blister copper, and supplies, as expeditiously as possible. They would also have to be equipped for loading the products of the refinery. The initial cost would vary with the location and with the size of the plant.

5. *Subsidiary Industries.*—If it were decided to establish shops to produce copper wire or bars, plates, and tubes, the additional capital expenditure required would vary from about \$300,000 to \$500,000, according to the capacity of the plant and the variety of its products.

6. *Working Capital.*—It is not possible, at the present stage, to arrive at any satisfactory estimate as to the amount of working capital required. Under ordinary circumstances it is probable that about \$300,000 would be required for the refinery and \$500,000 for the smelter, over and above that needed for the erection and equipment of the plants. The exceptional circumstances attendant on the marketing of the products of the refinery, because of its location, may render it necessary to have a very much larger working capital.

Copper refiners, as a rule, do not purchase the copper treated at their works. They usually levy a fixed treatment charge, and make a percentage deduction from the weight of the crude copper received to compensate losses in treatment. This fixed charge varies with the nature of the product to be treated from \$10 to about \$20 per ton. They also pay for the gold and silver recovered at current market rates. In the eastern refineries the copper in transit is rarely tied up for more than a week or ten days, exclusive of time consumed in transportation. In a refinery on the British Columbia coast it is probable that the copper in transit through the works and *en route* to market would be tied up for at least a month. and possibly for two months or more. It seems probable, therefore, that there would never be less than 3,000,000 lbs. of copper locked up, and very frequently the amount in transit would be double this quantity. At an average market value of 12 cents per pound this means the loss of interest on a sum of money lying between \$350,000 and \$750,000, according to the circumstances. Since nearly all the available copper ores, mattes, and blister copper also contain small quantities of gold and silver, the value of these metals, when in transit through the works, would also have to be considered. Their probable value cannot be readily estimated without an accurate knowledge of the products to be treated in the

plant. The length of time these metals would be locked up would probably not be less than two weeks, and never more than four.

It is thus apparent that the circumstances of location and marketing may entail a somewhat larger interest loss on metals in transit than would normally occur, and compensatory adjustments for this extra charge would probably have to be made by the refinery. It is not possible to state how much extra capital would be required to provide for this contingency.

7. *Summary.*—Summarizing the foregoing it appears probable that the approximate capital expenditure needed to establish, on the Pacific coast of British Columbia, a plant capable of producing 50 tons of refined copper per day would be about three-quarters of a million dollars, assuming that the equipment is entirely new. An auxiliary smelter to treat the ores that would be available, but for which there is no present smelter capacity, would cost at least an equal sum. The amount of working capital needed for the refinery would be not less than $300,000, and for the smelter about $500,000.

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4. *GENERAL CONCLUSIONS.*

The author's conclusions may be very briefly stated as follows:—

1. The province of British Columbia is the only province which produces enough copper annually to support an electrolytic copper refinery.

2. Within a very short period of time the total amount of copper produced from districts tributary to the Pacific Coast of British Columbia will probably be more than half the total production of Canada, and will be much in excess of that tributary to interior points.

3. For various reasons, which have been cited, the author concludes that the Pacific Coast of British Columbia offers the best choice of sites for a refinery.

4. The Canadian consumer does not demand refined copper in any quantity, but purchases copper in manufactured forms; therefore refined copper produced in Canada would for the most

part be unsaleable unless provision is also made for its conversion into manufactured forms, particularly bars, rods, wire, sheets and tubes.

5. A market for the surplus copper would have to be obtained. It is probable that refined copper could be marketed in Europe as cheaply as from a refinery in the eastern United States. It is also possible that the Australian and the Asiatic markets might require the surplus material if converted into manufactured products.

6. There appears to be an opening for the organization of a very considerable commercial enterprise which might include among its activities the following principal departments:—

(*a*) Copper smelter (treating about 500 tons of ore per day).
(*b*) Copper refinery (producing about 50 tons of copper daily).
(*c*) Zinc smelter (producing about 40 tons of zinc daily, including zinc in oxide).
(*d*) Brass making plant.
(*e*) Rolling mills (for copper, zinc, and brass).
(*f*) Bar and wire mill.
(*g*) Tube mill.

7. The organization of any considerable commercial enterprise founded on the copper productive capacity of British Columbia is dependent upon the securing of the contracts for refining the output of the Granby Mining, Smelting and Power Company's production at Anyox, and that of the Britannia Mining and Smelting Company at Britannia Mines. To secure the co-operation of these two large producers it will be necessary to approach them in a business-like way with reasonable proposals which it will be to their material advantage to accept. These proposals must be supported by suitable guarantees to insure that any agreement made can be carried out.

8. The financing of any operation of this magnitude at this time might be difficult. It is therefore desirable that the Government consider in what way the financing of such an enterprise could be assisted. It is probable that the enterprise itself should be handled as a private commercial venture.

9 The organization of a corporation to erect a copper refinery and to carry on the associated industries here suggested is a matter for private enterprise and it is not necessary to discuss methods of procedure in this report.

5. *STATISTICS FOR CANADA OF COPPER AND BRASS*

The following pages showing the statistics of Canadian production of the metals copper and zinc are taken from the Annual Report for 1914 of Mr. John McLeish, Chief of the Division of Mineral Resources and Statistics.

COPPER.

The total production of copper in Canada in 1914 estimated on the basis of smelter recovery from ores treated, was 75,735,960 pounds, which, at the average price of copper for the year in New York 13.602 cents per pound, would be worth $10,301,606.

Since 1912 there has been a gradual falling off in quantity, and owing to the decrease in the price of the metal, a still greater falling off in value.

In the case of British Columbia the metal is mainly derived from ores low in copper content and since in smelting the copper, losses are necessarily high, running as high in some cases as 25 per cent. and over, the difference between the copper content of the ore as shipped by the mine and the metal recovered from the ore at the smelter, is considerable.

Statistics of the copper production for the years previous to 1909 include, for British Columbia, a record of the copper production in that province as collected by the Provincial Bureau of Mines. These are compiled on the basis of the total metal content of the ores received at the smelters for which smelter returns were received during the year, and show a relatively higher copper production than the figures published for the Province of Ontario, which were based on copper content of matte produced.

Since 1909 the method of compilation of statistics of copper production by the Provincial Bureau of Mines in British Columbia provides for a deduction of five lbs. of copper per ton of ore shipped on account of smelter losses, a method which gives a result closely approximating to that obtained by this Branch.

PRODUCTION OF COPPER BY PROVINCES 1911, 1912, 1913 AND 1914.

Province.	1911.		1912.	
	Lbs.	Value.	Lbs.	Value.
		$		$
Quebec	2,436,190	301,503	3,282,210	536,346
Ontario	17,932,263	2,219,297	22,250,601	3,635,971
British Columbia	35,279,558	4,366,198	50,526,656	8,256,561
Other districts*	....	....	1,772,660	289,670
Total	55,648,011	6,886,998	77,832,127	12,718,548

Provinces.	1913		1914	
	Lbs.	Value.	Lbs.	Value.
		$		$
Quebec	3,445,887	527,679	4,201,497	571,488
Ontario	25,885,929	3,952,522	28,948,211	3,937,536
British Columbia	45,791,579	6,991,916	41,219,202	5,606,636
Other districts*	1,843,530	281,489	†1,367,050	185,946
Total	76,976,925	11,753,606	75,735,960	10,301,606

*Includes Nova Scotia and Yukon. †Yukon only.

Prices:—The price of copper in New York varied between a maximum of 14.70 cents in February and a minimum of 11.05 cents in November. For three months following the declaration of war there were no market quotations. By the end of December prices had increased again to 13 cents.

The monthly average prices in cents per lb. of electrolytic copper in New York are shown for a period of five years in the accompanying table:—

MONTHLY AVERAGE PRICES OF ELECTROLYTIC COPPER IN NEW YORK.

Months	1909	1910	1911	1912	1913	1914
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
January	13.893	13.620	12.295	14.094	16.488	14.233
February	12.949	13.332	12.256	14.084	14.971	14.491
March	12.387	13.255	12.139	14.698	14.713	14.131
April	12.563	12.733	12.019	15.741	15.291	14.211
May	12.893	12.550	11.989	16.031	15.436	13.996
June	13.214	12.404	12.385	17.234	14.672	13.603
July	12.880	12.215	12.463	17.190	14.190	13.223
August	13.007	12.490	12.405	17.498	15.400	*
September	12.870	12.379	12.201	17.508	16.328	*
October	12.700	12.553	12.189	17.314	16.337	*
November	13.125	12.742	12.616	17.326	15.182	11.739
December	13.298	12.581	13.552	17.376	14.224	12.801
Yearly average	12.982	12.738	12.376	16.341	15.269	13.602

In London the monthly average prices of standard copper were as follows in pounds sterling per ton of 2,240 lbs.:—

MONTHLY AVERAGE PRICES OF STANDARD COPPER IN LONDON.

Months	1909	1910	1911	1912	1913	1914
	£	£	£	£	£	£
January	57.688	60.923	55.604	62.760	71.741	64.304
February	61.197	59.388	54.970	62.893	65.519	65.259
March	56.231	59.214	54.704	65.884	65.329	64.276
April	57.363	57.238	54.035	70.294	68.111	64.747
May	59.338	56.313	54.313	72.352	68.807	63.182
June	59.627	55.310	56.368	78.259	67.140	61.336
July	58.556	54.194	56.670	76.636	64.166	60.540
August	59.393	55.733	56.264	78.670	69.200	*
September	59.021	55.207	55.253	78.762	73.125	*
October	57.551	56.722	55.176	76.389	73.383	*
November	58.917	57.634	57.253	76.890	68.275	53.227
December	59.906	56.069	62.063	75.516	65.223	56.841
Yearly average	58.732	57.054	55.973	72.942	68.335	61.524

*No quotations.

Statistics showing the annual copper production of Canada since 1886 are given in the following table, which shows the yearly increase or decrease as the case may be and also the yearly price per lb. in New York:—

ANNUAL PRODUCTION OF COPPER.

Calendar Year	Lbs.	Increase or decrease		Value	Increase or decrease		Average price per pound.
		Lbs.	%		$	%	
				$			Cts.
1886........	3,505,000	....	....	385,550	....	....	11.00
1887........	3,260,424	(d) 244,576	6.99	366,789	(d) 18,752	4.86	11.25
1888........	5,562,864	2,302,440	70.60	927,107	560,309	152.70	16.66
1889........	6,809,752	1,246,888	22.40	936,341	9,234	0.99	13.75
1890........	6,013,671	(d) 796,081	11.69	947,153	10,812	1.15	15.75
1891........	9,529,401	3,515,730	58.46	1,226,703	279,550	29.51	12.87
1892........	7,087,275	2,442,126	25.63	818,580	(d) 408,123	33.27	11.55
1893........	8,109,856	1,022,381	14.40	871,809	53,229	6.50	10.75
1894........	7,708,789	(d) 401,067	4.94	736,960	(d) 134,849	15.46	9.56
1895........	7,771,639	62,850	0.81	836,228	99,268	13.47	10.76
1896........	9,393,012	1,621,373	20.86	1,021,960	185,732	22.21	10.88
1897........	13,300,802	3,907,790	41.60	1,501,660	479,700	46.94	11.29
1898........	17,747,136	4,446,334	33.43	2,134,980	633,320	42.17	12.03
1899........	15,078,475	(d) 2,668,661	15.04	2,655,319	520,339	24.37	17.61
1900........	18,937,138	3,858,663	25.59	3,065,922	410,603	15.46	16.19
1901........	37,827,019	18,889,881	99.75	6,096,581	3,030,659	98.84	16.117
1902........	38,804,259	977,240	2.58	4,511,383	(d) 1,585,198	26.00	11.626
1903........	42,684,454	3,880,195	10.00	5,649,487	1,138,104	25.23	13.235
1904........	41,383,722	(d) 1,300,732	3.05	5,306,635	(d) 342,852	6.07	12.823
1905........	48,092,753	6,709,031	16.21	7,497,660	2,191,025	41.29	15.590
1906........	55,609,888	7,517,135	15,63	10,720,474	3,222,814	42.98	19.278
1907........	56,979,205	1,369,317	2.46	11,398,120	677,654	6.32	20.004
1908........	63,702,873	6,723,668	11.80	8,413,876	2,984,244	26.18	13.208
1909*.......	52,493,863	....	....	6,814,754	....	....	12.982
1910........	55,692,369	3,198,506	6.09	7,094,094	279,340	4.10	12.738
1911........	55,648,011	(d) 44,358	0.79	6,886,998	(d) 207,096	2.92	12.376
1912........	77,832,127	22,184,116	28.50	12,718,548	5,831,550	45.85	16.341
1913........	76,976,925	(d) 855,202	1.10	11,753,606	(d) 964,942	7.59	15.269
1914........	75,735,960	(d) 1,240,965	1.64	10,301,606	(d) 1,452,000	14.10	13.602

*The decrease is not as large as the figures would indicate because of the calculation of part of the 1909 production on a different basis from previous years. (See explanation in text.)

With the exception of a small output of copper sulphate at Trail, B.C., the copper production of Canada is exported for refining. The exports of copper on ore, matte, regulus, etc., during the calendar year 1914 were 68,830,059 pounds valued at $7,130,778, of which 57,923,363 pounds valued at $6,287,439 were exported to the United States, and 10,906,696 pounds valued at $843,339 to Great Britain. The exports of copper black or coarse and in pigs, to the United States amounted to 6,581,564 pounds valued at $908,201. There was also an export

of "old and scrap" copper amounting to 19,871 cwt. and valued at $231,710, distributed as follows: to the United States 16,604 cwt. valued at $189,793; to Great Britian, 2,751 cwt. valued at $35, 918; and to other countries 516 cwt. valued at $5,999.

The following tables give, in detail, the exports for 1913 and 1914:—

Exports of Copper 1913 and 1914.

1914.	Fine in ore, matte, regulus, etc.		Black or coarse and in pigs.		"Old and Scrap."	
	Pounds.	Value. $	Pounds.	Value. $	Cwt.	Value. $
United States....	57,932,363	6,287,439	6,581,564	908,201	16,604	189,793
Great Britain....	10,906,696	843,339	....	....	2,751	35,918
Other Countries..	....	....	....	....	516	5,999
Total.......	68,830,059	7,130,778	6,581,564	908,201	19,871	231,710
1913.						
United States....	76,552,312	9,079,167	771,280	123,431	18,432	237,678
Great Britain....	5,325,468	400,163	....	....	6,071	80,647
Other Countries..	1,300	150	....	....	469	6,578
Total.......	81,879,080	9,479,480	771,280	123,431	24,972	324,903

EXPORTS OF COPPER IN ORE, MATTE, ETC.

Calendar Year.	Lbs.	Value.	Calendar Year.	Lbs.	Value.
		$			$
1885............	....	262,600	1900..........	23,631,523	1,741,885
1886............	....	249,259	1901..........	32,488,872	3,404,908
1887............	....	137,966	1902..........	26,094,498	2.476,516
1888............	....	257,260	1903..........	38,364,676	3,873,827
1889............	....	168,457	1904..........	38,553,282	4,216,214
1890............	....	398,497	1905..........	40,740,861	5,443,873
1891............	....	348,104	1906..........	42,398,538	7,303,366
1892............	....	277,632	1907..........	54,688,450	8,749,609
1893............	4,792,201	269,160	1908..........	51,136,371	5,934,559
1894............	1,625,389	91,917	1909..........	54,447,750	5,832,246
1895............	3,742,352	236,965	1910..........	56,964,127	5,840,553
1896............	5,462,052	281,070	1911..........	55,287,710	5,467,725
1897............	14,022,610	850,336	1912..........	78,488,564	9,036,479
1898............	11,572,381	840,243	1913*.........	85,147,560	9,927,814
1899............	11,371,766	1,199,908	1914*.........	77,398,723	8,270,689

*Includes "Old and Scrap."

The total imports of copper during the calendar year were valued at $4,256,901 and include crude and manufactured copper to the extent of 26, 280, 815 pounds valued at $3,983,322. Copper sulphate 1,143,039 pounds valued at $53,802, and other manufactures of copper valued at $219,777.

In 1913 the total value of the imports was $7,414,610 and included 41,011,961 pounds of crude and manufactured copper valued at $6,935,822; copper sulphate 2,037,714 pounds valued at $107,960; and other copper manufactures valued at $370,828.

Imports of Copper 1913 and 1914.

	1913.		1914.	
	Pounds.	Value.	Pounds.	Value.
		$		$
Copper, old and scrap	596,700	87,790	127,800	15,717
Copper in pigs, ingots or in blocks	5,314,200	845,095	3,733,300	507,499
Copper in bars, and rods, in coils, or otherwise, in lengths, not less than 6 ft. unmanufactured	29,387,90	0 4,886,846	18,212,300	2,689,940
Copper, in strips, sheets or plates, not planished or coated, etc.	4,255,900	782,974	3,373,100	574,783
Copper tubing in lengths not less than 6 feet and not polished, bent or otherwise manufactured	884,920	205,797	696,444	159,602
Copper rollers, for use in calico printing	....	11,704	....	22,301
Copper and Manufactures of:—				
Nails, tacks, rivets and burrs or washers	....	3,479	....	4,445
Wire, plain, tinned or plated	572,341	127,320	137,871	35,781
Wire cloth, etc.	....	5,844	....	4,433
All other manufactures of, n.o.p.	....	349,286	....	188,2
Copper precipitate of crude	4,743	515	2,017	328
Copper sulphate	2,037,714	107,960	1,143,039	53,802
Total value	....	74,147.610	....	4,256,901

Imports of Copper 1910 to 1914 inclusive.

Year.	Pigs, ingots or in blocks		Old and Scrap.		Crude precipitate.	
	Lbs.	$	Lbs.	$	Lbs.	$
1910	4,640,500	609,111	273,700	31,070	4,847	595
1911	5,650,400	705,598	265,300	28,748	2,608	299
1912	5,121,800	806,705	400,500	56,748	5,703	570
1913	5,314,200	845,095	596,700	87,790	4,743	515
1914	3,733,300	507,499	127,800	15,717	2,017	328

IMPORTS OT COPPER 1910 TO 1914 INCLUSIVE.—(*Continued*).

Year.	Manufactures of Copper. Bars, rods, sheets, tube and wire.		Manufactures of Copper. Other manufactures.	Copper sulphate.		Total Value.
	Lbs.	$	$	Lbs.	$	$
1910	25,322,906	3,579,270	150,322	1,925,557	77,782	4,448,150
1911	29,244,210	3,898,416	215,289	2,191,899	88,419	4,936,769
1912	35,198,208	5,776,003	305,680	2,105,419	101,650	7,047,356
1913	35,101,061	6,002,937	370,313	2,037,714	107,960	7,414,610
1914	22,419,715	3,460,106	219,449	1,143,039	53,802	4,256,901

COPPER:—IMPORTS OF PIGS, OLD SCRAP, ETC.

Fiscal Year.	Lbs.	Value.	Fiscal Year.	Lbs.	Value.
		$			$
1880	31,900	2,130	1898	1,050,000	80,000
1881	9,800	1,157	1899	1,655,000	246,740
1882	20,200	1,984	1900	1,144,000	180,990
1883	124,500	20,273	1901	951,500	152,274
1884	40,200	3,180	1902	1,767,200	325,832
1885	28,600	2,016	1903	2,038,400	252,594
1886	82,000	6,969	1904	2,115,300	270,315
1887	40,100	2,507	1905	1,944,400	266,548
1888	32,300	2,322	1906	2,627,700	441,854
1889	32,300	3,288	1907 (9 mos.)	2,616,600	520,971
1890	112,200	11,521	1908	3,612,400	650,597
1891	107,800	10,452	1909	2,732,300	383,441
1892	343,600	14,894	1910	4,914,200	640,181
1893	168,300	16,331	1911	5,915,700	734,346
1894	101,200	7,397	1912	5,522,300	863,453
1895	72,062	6,770	1913	5,910,900	932,885
1896	86,905	9,226	1914	3,861,100	523,216
1897	49,000	5,449			

IMPORTS OF MANUFACTURES OF COPPER.

Fiscal Year.	Value.	Fiscal Year.	Value.	Fiscal Year.	Value.
	$		$		$
1880	123,061	1892	422,870	1904	1,191,610
1881	159,163	1893	458,715	1905	1,775,881
1882	220,235	1894	175,404	1906	2,660,303
1883	247,141	1895	251,615	1907 (9 mos.)	2,545,600
1884	134,534	1896	285,220	1908	2,713,060
1885	181,469	1897	264,587	1909	2,086,205
1886	219,420	1898	786,529	Calendar Year.	
1887	325,365	1899	551,586	1910	1,717,542
1888	303,459	1900	1,090,280	1911	4,113,395
1889	402,216	1901	951,045	1912	6,081,464
1890	472,668	1902	1,281,522	1913	6,373,250
1891	563,522	1903	1,291,635	1914	3,679,555

QUEBEC.

The mines of the Eastern Townships were still more active during 1914 with an increased copper production therefrom. This amounted to 4,206,497 pounds, valued at $571,488, representing the estimated recovery from 117,699 tons of ore and concentrates. Statistics of the copper production of Quebec province since 1886 are shown in the table following:—

QUEBEC.—PRODUCTION OF COPPER.

Calendar Year.	Lbs.	Value.	Calendar Year.	Lbs.	Value.
		$			$
1886	3,340,000	367,400	1900	2,220,000	359,418
1887	2,937,900	330,514	1901	1,527,442	246,178
1888	5,562,864	927,107	1902	1,640,000	190,666
1889	5,315,000	730,813	1903	1,152,000	152,467
1890	4,710,606	741,920	1904	1,760,000	97,455
1891	5,401,704	695,469	1905	621,243	252,752
1892	4,883,480	564,042	1906	1,981,169	381,930
1893	4,468,352	480,348	1907	1,517,990	303,659
1894	2,176,430	208,067	1908	1,282,024	169,330
1895	2,242,462	241,288	1909	1,088,212	141,272
1896	2,407,200	261,903	1910	877,347	111,757
1897	2,474,970	279,424	1911	2,436,190	301,503
1898	2,100,235	252,658	1912	3,282,210	536,346
1899	1,632,560	287,494	1913	3,455,887	527,679
			1914	4,201,497	571,488

ONTARIO.

The copper production from Ontario comes mainly from the nickel-copper ores of Sudbury district.

The chief companies are: The Canadian Copper Co., Limited, shipping from Creighton, Cream Hill, the No. 2 and the No. 3, or Frood mines; and the Mond Nickel Co., Limited, operating the Garson, Victoria No. 1, North Star and Worthington. The Alexo mine, near Porquis Junction, on the Timiskaming and Northern Ontario Railway, shipped a considerable tonnage of nickel-copper ore to the Mond Nickel Company's smelter.

The British America Nickel Corporation did some development work at the Murray and Whistle mines, but made no production.

A small shipment was made of copper ore from Dane to United States smelters, and payments were made for a small amount of copper in shipments from the Colbalt district to American smelters.

The total tonnage of nickel-copper ores smelted in 1914 was 947,053 tons. There were produced during the year 46,396 tons of bessemer matte, containing 14,448 tons of copper and 22,759 tons of nickel, the shipping value of these matte being approximately $7,189,031. Details of the production of these ores are given more completely and in tabular form in the article on "Nickel."

The Ontario Government offers a bounty on copper over 95 per cent. pure metal, and on copper-sulphate produced from ore mined and refined in the Province. The text of the Act will be found in the chapter on cobalt under the heading "Metal Refining Bounty Act."

Statistics of the copper production of Ontario since 1886 are given in the table following:—

ONTARIO.—PRODUCTION OF COPPER.

Calendar Year.	Lbs.	Value.	Calendar Year.	Lbs.	Value.
		$			$
1886	165,000	18,150	1900	6,740,058	1,091,215
1887	322,524	36,284	1901	8,695,831	1,401,507
1888	Nil.	Nil.	1902	7,408,202	861,278
1889	1,466,752	201,678	1903	7,172,533	949,285
1890	1,303,065	205,233	1904	4,913,594	630,070
1891	4,127,697	531,234	1905	8,779,259	1,368,686
1892	2,203,795	254,538	1906	10,638,231	2,050,838
1893	3,641,504	391,461	1907	14,104,337	2,821,432
1894	5,207,679	497,854	1908	15,005,171	1,981,883
1895	4,576,337	492,414	1909	15,746,699	2,044,237
1896	3,167,256	344,598	1910	19,259,016	2,453,213
1897	5,500,652	621,023	1911	17,932,263	2,219,297
1898	8,375,223	1,007,539	1912	22,250,601	3,635,971
1899	5,723,324	1,007,877	1913	25,885,929	3,952,522
			1914	28,946,211	3,937,536

BRITISH COLUMBIA.

According to returns received from the smelters, the total quantity of copper contained in matte, blister, and copper-sulphate produced in British Columbia during 1914, and including and estimate of smelter recovery for copper ores exported, was

41,219,202 pounds, after deducting the amount of copper produced from foreign ores. The production of 1913 on a similar basis was 45,791,579 pounds, and in 1912—50,526,656 pounds.

Returns of smelter production in this Province were not collected by this Department previous to 1908, and a complete record of statistics of production on this basis is not available.

The production of copper in this Province, according to statistics collected and published by the Provincial Department of Mines, reached a total of 45,009,699 pounds in 1914, as compared with 46,460,305 pounds in 1913. Statistics of the annual production since 1894, as ascertained by the Provincial Department of Mines, and the production by districts since 1908 are shown in the tables following:—

BRITISH COLUMBIA.
COPPER CONTENT OF ORES SHIPPED.†

Calendar Year.	Copper contained in ores shipped.	Increase.		
	Lbs.	Lbs.	%	Value.
				$
1894	324,680	....	....	31,039
1895	952,840	628,160	193.0	102,526
1896	3,818,556	2,865,716	301.0	415,459
1897	5,325,180	1,506,624	39.0	601,213
1898	7,271,678	1,946,498	36.0	874,783
1899	7,722,591	450,913	6.0	1,359,948
1900	9,977,080	2,254,489	29.0	1,615,289
1901	27,603,746	17,626,666	177.0	4,448,896
1902	29,636,057	2,032,311	7.0	3,445,488
1903	34,359,921	4,723,864	16.0	4,547,735
1904	35,710,128	1,350,207	3.7	4,579,110
1905	37,692,251	1,982,123	5.6	5,876,222
1906	42,990,488	5,298,237	14.1	8,287,706
1907	40,832,720	*2,157,768	*5.02	8,168,177
1908	47,274,614	6,441,894	15.8	6,244,031
1909	45,597,245	*1,677,369	*3.6	5,918,522
1910‡	38,243,934	....	....	4,871,512
1911‡	36,927,656	*1,316,278	*3.4	4,571,644
1912‡	51,546,537	14,618,881	39.6	8,408,513
1913‡	46,460,305	*4,996,232	9.7	7,094,489
1914‡	45,009,699	*1,450,606	3.1	6,121,319

*Decrease. †As published by British Columbia Bureau of Mines. ‡Allowing 5 pounds copper per ton of ore for smelter losses.

BRITISH COLUMBIA.

PRODUCTION OF COPPER BY DISTRICTS.

——	1908*	1909*	1910†	1911†	1912†	1913	1914
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Cariboo.....	....	....	....	....	....	1,838	6,000
Cassiar.....	490,873	137,651	....	19,151	88,403	1,336	11,123,376
W. Kootenay							
Nelson.....	53,243	186,572	231,936	....	26,257	815,126	586,764
Trail Creek.	5,042,244	3,509,909	3,577,745	3,429,702	2,539,900	2,538,661	3,779,830
Yale—							
Boundary..	40,178,521	40,603,042	31,354,985	22,327,359	33,372,199	28,621,973	16,428,959
Ashcroft							
Kamloops..	3,269	....	1,178	152,723	....	37,578	14,525
Coast distr'ts	1,506,464	1,160,071	3,077,090	10,998,721	15,429,778	14,443,793	13,070,245
Total.....	47,274,614	45,597,245	38,342,934	36,927,656	51,456,537	46,460,305	45,009,699

*Copper content of ores shipped. †After deducting five pounds of copper per ton of ore for slag losses.

According to the direct returns in 1914, the ores of the Boundary district produced 42.9 per cent. of the total against 63.5 per cent. of the total for 1913; the Trail Creek and Nelson divisions came in for about 11.3 per cent.; and the Coast and Cassiar districts for 45.8 per cent.—compared with 29.8 per cent. of the total for 1913.

In the Boundary the production was mainly from the mines of three of the large smelting companies; the Granby Consolidated Mining, Smelting and Power Co., Limited; the British Columbia Copper Co., Limited, and the New Dominion Copper Co., Limited. The two first named operate their own smelters and convert their matte to blister copper. The low grade ores of this district are self-fluxing and very uniform in character, averaging a little over 1 per cent. in copper, and from $1 to $2 in gold and silver.

The chief producing mines of the district were the Granby mines at Phoenix, the Mother Lode of the British Columbia Copper Company at Deadwood, and Rawhide of the New Dominion Copper Company, near Phoenix.

The British Columbia Copper Company have been steadily developing their properties at Princess Camp in the Similkameen, employing a large number of men. The properties were producing

during 1914 and we may look forward to the eventual establishment in that part of the country of another important copper producing centre.

In the interior the main shippers were, at Rossland, the Centre Star, Le Roi groups, owned by the Consolidated Mining and Smelting Co., and the Le Roi II (Josie) mine. Besides these, shipments were made from the Nelson district by the Queen Victoria mine of the British Columbia Copper Co., and the Silver King of the Consolidated Mining and Smelting Company.

Much development was done in the neighbourhood of New Hazelton in the Omineca mining division.

The Montana Continental Development Co., did extensive improvements and much work on the Rocher de Boule property, and will likely be an important producer in 1915.

The decrease in production in the Boundary district was more than offset by the large increase in production of the Coast district, which now ranks as the principal producer of copper ores in British Columbia with heavy shipments from the Hidden Creek mine on Observatory inlet; the Britannia mines on Howe Sound and the Marble Bay mines on Texada Island.

YUKON.

The main shipments from this Territory were from the Pueblo mine at Whitehorse. Some smaller properties also shipped and the owners of the Pueblo have re-opened the War Eagle in the same neighbourhood.

IMPORTS OF COPPER

From Reports of Department of Customs, for fiscal year ending March 31st.

		1913.		1914.	
		Cwt.	$	Cwt.	$
Copper, old and scrap...........	B. W. Indies,	16	97	....	....
	Newfoundland and Labrador........	52	470	13	122
	United States......	5,623	81,707	4,310	62,045
	B. Guiana.........	....	....	82	922
	Total...........	5,691	82,274	4,405	63,089

IMPORTERS OF COPPER.—(*Continued*)

		1913		1914	
		Cwt.	$	Cwt.	$
Copper, in blocks, pigs, or ingots...	United Kingdom...	500	7,313	410	6,636
	United States......	50,716	840,081	49,995	778,094
	Germany..........	....	....	551	8,131
	Total..........	51,216	847,394	50,956	792,861
Copper, in bars and rods in coil or otherwise.......	United Kingdom....	7,077	107,143	202	4,217
	United States......	298,656	4,996,701	270,051	4,333,471
	Germany..........	....	....	29	511
	Total..........	305,733	5,103,844	270,282	4,338,199
Copper, in strips, sheets or plates ...	United Kingdom...	1,037	21,287	329	5,890
	United States......	43,774	852,783	39,531	718,956
	Germany..........	....	....	17	323
	Total..........	44,811	874,070	39,877	725,169
Copper tubing....	United Kingdom...	231,229	50,777	110,019	25,108
	Belgium...........	6,040	949	820	188
	Germany..........	170,249	34,096	189,780	41,621
	Holland...........	100	20	12,298	2,610
	United States......	481,438	115,375	500,992	120,940
	Sweden............	....	....	10,150	1,855
	Total..........	889,056	201,217	824,059	192,322
Copper rollers.....	United Kingdom...	....	3,154	....	9,415
	France............	....	1,113	....	....
	Germany..........	....	866	....	....
	United States......	....	3,541	....	18,853
	Total..........	....	8,674	....	28,268

IMPORTS OF BRASS

From Reports of Department of Customs, for fiscal year ending March 31st.

		1913.		1914.	
		Cwt.	$	Cwt.	$
Brass, old and scrap...........	United Kingdam...	502	7,256	138	2,088
	Bermuda..........	58	260	....	....
	B. Guiana.........	66	664	25	226
	B. W. Indies.......	61	357	4	27
	Newfoundland and Labrador........	92	917	209	1,733
	Germany..........	93	1,634	....	....
	Miquelon and St. Pierre...........	18	127	....	....
	United States......	43,617	542,190	24,980	291,667
	Denmark..........	....	....	2	24
	Total..........	44,487	553,405	25,358	295,765

IMPORTS OF BRASS—(*Continued*).

		1913		1914	
		Cwt.	$	Cwt.	$
Brass, in blocks, ingotsor pigs...	United Kingdom...	102	2,172	....	....
	United States......	19,820	292,526	17,663	232,831
	Germany..........	....	....	199	2,367
	Total..........	19,922	294,698	17,862	235,198
Brass tubing......	United Kingdom....	479,186	94,794	344,075	67,987
	Belgium...........	5,210	985	35,840	5,695
	Germany..........	148,499	26,667	139,242	29,923
	United States......	1,621,989	348,747	1,436,659	313,836
	Holland...........	....	....	80	16
	Total..........	2,254,884	471,193	1,995,896	417,457
		Cwt.		Cwt.	
Brass bars or rods.	United Kingdom...	1,183	20,795	804	13,461
	Germany..........	62	1,024	538	8,591
	United States......	53,254	912,290	46,507	735,148
	Total..........	54,499	934,109	47,849	757,200

	1915. (11 mos.)
Brass, old and scrap..	1,197,700 lbs.
Brass in blocks, ingots or pigs..............................	759,000 lbs.
Brass tubing..	1,466,598 lbs.
Brass bars or rods..	544,000 lbs.

COPPER.

Prices.

Average during 1914:—

Electrolytic...... 13·31½ cts. per lb.

Lake............ 13·61 cts. per lb.

Highest during past ten years:—

Electrolytic...... 20·86 in 1907.

Lake............ 26·25 in 1907.

Lake prices for last 30 years:—

High............ 26·25 in 1907.

Low............ 9·00 in 1894.

Average......... 13·84

Production.

United States for 1904... 812,537,267 lbs.

United States for 1906... 917,805,682 lbs.

United States for 1914... 1,129,000,000 lbs.

Consumption.

United States for 1904... 882,190,920 lbs. (estimated).

United States for 1906... 686,265,987 lbs. "

United States for 1914... 570,000,000 lbs. "

SECTION XI.

REPORT

To Honorary-Colonel David Carnegie, M.Inst.C.E., on

THE ECONOMIC POSSIBILITY OF PRODUCING METALLIC ZINC COMMERCIALLY IN CANADA.

By Alfred Stansfield, D.Sc., A.R.S.M., F.R.S.C., Professor of Metallurgy of McGill University.

June, 1915.

McGill University
Montreal, April, 1915.

Sir:—

At your suggestion the Hon. General Hughes requested Principal Peterson to detail me for service on your Commission of Enquiry into the possibility of establishing in Canada a copper refinery and a zinc smelter. I made a preliminary examination of the situation before leaving Montreal and then accompanied you and Dr. Wilson on a visit to points in British Columbia and other parts of western Canada where information could be obtained in regard to the subject of your enquiry.

While taking a share in the whole investigation, I have devoted especial attention to that part of the enquiry that related to the production of zinc, and I submit herewith my report on that subject.

I am,
Sir, yours respectfully,
(Sgd.) A. STANSFIELD,

Col. David Carnegie, F.R.S.E., M.Inst.C.E.,
Shell Committee,
Montreal.

Report on the Economic Possibility of Producing Metallic Zinc Commercially in Canada.

INTRODUCTION.

Ores containing some 3,000–4,000 tons of zinc are exported annually from Canada to the zinc smelters in the United States, and some 8,000 tons of metallic zinc, besides other zinc products, are imported into Canada, so that the question arises whether the Canadian ores of this metal cannot be smelted in Canada to supply the Canadian market. The production of zinc in Canada has been under consideration for a number of years, but it has recently become more urgent in view of the use of this metal in the manufacture of ammunition for the present war.

An investigation of this question may be divided into the following sections:—

1. The amount, distribution and character of the Canadian ores.
2. The existing methods of utilizing these ores.
3. An account of the attempts which have already been made to treat these ores in Canada.
4. The conclusions arrived at as the result of the present investigation.
5. Appendices to the Report. The main report, included under sections 1 to 4, has been condensed as far as possible, and the full data and dicussions are contained in a series of appendices in section 5.

1. *CANADIAN ZINC ORES.*

The zinc ores in Canada and the extent to which they can be concentrated and prepared for smelting operation has been dealt with recently by Mr. W. R. Ingalls,* whose report must form the basis of any discussion of this subject; Dr. Wilson in his report has considered the distribution of zinc ores, and additional particulars will be found in the appendix to this report. The whole situation may be summed up briefly as follows:—

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*Report of the Commission appointed to investigate the Zinc Resources of British Columbia and the conditions affecting their exploitation; Ottawa, 1906.

1. The present production of Canadian ores is obtained chiefly from British Columbia, and especially from the Kootenays.

2. The ores are, in general, obtained from mines whose main products are lead and silver; the zinc ores are rather low grade and are usually mixed with the lead and silver ores from which they cannot readily be separated.

3. Zinc ores, unless they are rich in silver, must contain 40% to 45% of zinc if they are to be sold at a profit to the United States smelters, under normal conditions. Some 7,000–9,000 tons of such zinc ore and zinc concentrates, containing about 3,000–4,000 tons of zinc have been shipped annually in recent years.

4. If these ores could be sold to a Canadian smelting plant on more favourable terms than are now obtainable from the United States smelters, it is probable that the production of this class of ore would be stimulated, but it does not appear that any considerable increase could be counted upon.

5. In addition to the higher grade ores already referred to, there are in the mines in British Columbia large quantities of ores containing smaller percentages of zinc, usually associated with lead and silver, and of such a nature that it is not economially possible to separate the zinc minerals by the ore-dressing operations now in use so as to produce a saleable zinc ore. These ores are at present left in the mine or thrown away, because there is no method known by which they can be treated for the economical production of metallic zinc.

2. *EXISTING MEANS OF UTILIZING THE ORES.*

Nearly the whole output of Canadian zinc is obtained from mines that have lead and silver ores as their principal products; the zinc ore being a by-product. A small proportion of the zinc ore is obtained directly from the product of the mine with the aid of hand picking, but the ore from nearly all the mines contains minerals of lead, zinc and silver more or less intimately mixed and must be subjected to an ore-dressing treatment. The products of this operation are:—a lead-silver concentrate containing most of the lead with a little zinc, and a zinc concentrate; the latter contains say 30–45% zinc, 1–8% lead and 5–50 ozs. of silver per ton. The value of the lead concentrate is lessened by its zinc contents and the value of the zinc concentrate by its

lead contents, and in many cases the zinc product is not rich enough in that metal to be saleable under normal conditions. The zinc concentrate, if rich enough for the purpose, is shipped to smelters in the western States where it is treated, in admixture with other ores, by the standard American-Belgian method; natural gas being largely used as fuel.

The price paid by the smelters depends upon the composition of the ore and the market price of spelter and of silver, but it may be stated generally that when spelter is about 5c a pound the smelter pays the market price for nearly 50% of the zinc contents and for 75% of the silver contents of the ore in excess of 6 ozs. per ton. The miner has to pay the freight, which is about $10.00 per ton and the United States import duty which is 10% of the value of the zinc and $\frac{3}{4}$c per pound of the lead in the ore when this is over 3%. The net return to the miner has sometimes been as low as $3.00 or $4.00 per ton of concentrate.

At the present high price of spelter the sale of these concentrates would be more profitable and lower grade products could be shipped at a profit, but the smelters having large stocks of cheap ore in hand and a limited smelting capacity, do not wish to buy much ore at a high price. The Order-in-Council of the 27th April, 1915, prohibits the export of zinc ores from Canada to all countries outside the British Empire, but export to the United States is still permitted under license for manufacturing use in the States.

The ore from some mines is of such a nature that no saleable zinc product can be made and these are operated entirely on a silver-lead production. Large quantities of leady-zinc ores are now left in the mine that will become valuable as soon as an efficient method of treating these complex ores shall have been worked out.

The methods employed in dressing the ore are mostly of the ordinary variety including the use of jigs and tables, and while they are reasonably satisfactory as a means of producing a lead concentrate they are not very efficient in concentrating the zinc. It was pointed out in Mr. Ingalls' report in 1906 that the introduction of hand picking and of magnetic ore-dressing would produce better results than were obtained at that time, and the steady advance in ore-dressing will enable better recoveries of the zinc to be made and cleaner concentrates to be obtained for shipment.

3. *ATTEMPTS TO SMELT ZINC ORES IN CANADA.*

A serious attempt to smelt zinc ores in Canada was made about the year 1904 by the erection at Frank, Alberta, of a modern zinc smelter of the usual American-Belgian type. The place was selected in order to obtain a plentiful supply of cheap coal for fuel, as the amount of fuel required for this process is about three times the amount of ore smelted.

The plant was shut down after being operated for a short time, as it was found impossible to make spelter at a profit. It appears that the design of the plant and of the distilling furnaces was not entirely satisfactory, but the causes that probably let to the ultimate abandonment of the enterprise were the high cost of skilled labour and supplies, the poor quality of the coal and the limited amount and poor quality of the available ores.

Other attempts have been directed to the treatment of the ores that contain too little zinc and too much lead to be suitable for the regular Belgian process; of these attempts the most noteworthy is that of electric smelting.

There is apparently no reason why an ore containing lead, silver and zinc should not be smelted in an electric furnace so as to produce at a single operation lead-bullion and spelter. Up to the present, however, the results obtained are not good enough for commercial operation.

About 1908, Mr. F. T. Snyder of Chicago, aided by the British Columbia Government, erected an experimental plant at Nelson to smelt these lead-zinc ores in an electric furnace. The operation of his furnace was unsuccessful, however, and the plant was taken over by the British Columbia Government.

In 1910 pressure was put upon the Dominion Government to make experiments in the electric smelting of British Columbia ores, and Dr. Haanel enlisted the aid of Mr. W. R. Ingalls and myself in carrying out a series of small scale experiments on electric smelting at McGill University. The difficulties to be overcome proved more formidable than we had anticipated and the best results obtained were not good enough for commercial operation. It sometimes happens that a large furnace may work better than a small one, and Mr. Ingalls accordingly recommended tests on a larger scale in the Nelson plant. A furnace was

operated there for some months under his direction, but did not produce the desired results.

Mr. W. McA. Johnson has been carrying out experiments on electric smelting in the United States for a number of years and has apparently had somewhat better success than was obtained at Nelson.

Apart from electric smelting, a large number of processes have been devised for treating low grade zinc ores and lead-zinc ores. Many of these consist of roasting the ore in such a way as to produce zinc sulphate, dissolving this in water with the addition of sulphuric acid, and recovering the zinc by electrolysis or by precipitation by a chemical re-agent. Such methods have been tried many times and in many places, but have not been found commercially satisfactory. Two or three of these processes are now being tested in Canada, and in view of the recent advances in hydro-metallurgical methods it would not be safe to condemn them, in advance, on account of previous failures.

The Consolidated Mining and Smelting Company are testing, in their smelter at Trail, British Columbia, a leaching process of this nature for the complex Sullivan ores. The zinc sulphate solution, obtained by leaching the roasted ore with water and sulphuric acid, is electrolysed with insoluble lead anodes and zinc cathodes, but they have not as yet developed the process to a technically successful condition.

A modification of this process has been invented by Mr. French. The special features of this consist in the use of "nitre cake" (acid sulphate of soda) and manganese salts in the solution used for dissolving the ore. Mr. French obtained satisfactory deposits of metallic zinc, and his process has been tested at the Trail smelter. An experimental plant is to be erected at the Standard Mines near Silverton, British Columbia.

Another electrical process has been devised by Mr. E. E. Watts at Queen's University and is now being tested in my laboratory at McGill. In this process the ore is leached in the electrolytic tank instead of in separate vats, the roasted ore being placed in a compartment constructed of wood and canvas, that contains the anode. During electrolysis sulphuric acid is produced at the anode where it reacts with the roasted ore

forming zinc sulphate. The process appears to work satisfactorily, but the mechanical operations of charging and discharging the anode compartments may prove too costly for large scale operations. The Watts process has also been applied, on a small scale, to the production of metallic zinc from zinc oxide made by the Wetherill process or the bisulphite process, and it appears to be well adapted for this purpose.

The Wetherill process, which is in regular use in New Jersey, for making zinc white, consists in mixing roasted zinc ore with anthracite coal and charging the mixture upon a bed of burning coal on a grate of special design supplied with a forced blast. The zinc is volatilized and the resulting zinc oxide is caught by filtration in long woollen bags. The writer has tested this process on a small scale with several of the British Columbia ores and has obtained a satisfactory extraction of the zinc and the lead in the ores. The silver, however, passes partly into the fume and on this account the process could not be employed to make a lead-zinc paint from argentiferous ores, although the fume could be smelted in an electric furnace or treated by an electrolytic process for the recovery of zinc and lead. The Wetherill process uses an amount of coal that would be prohibitive unless a saleable paint were produced, but a modification of this process might be employed for the concentration of the lead and zinc contents of an ore. Experiments of this nature are being carried out at the Trail smelter.

Further particulars of these and of other methods that may prove suitable for the treatment of the complex British Columbia ores are given in section 5.

4. *CONCLUSIONS.*

The following are the conclusions that have been reached as the result of this investigation, together with an indication of the reasons leading up to them. Further particulars will be found in the appendices to this report.

1. It is not advisable, at the present time, to establish in Canada a zinc smelter of the standard type. The high cost of labour, fuel and supplies, handicaps any such smelter in Canada as compared with those in the United States. It might, nevertheless, be possible to smelt economically at a point like Medicine Hat where natural gas can be had at a nominal charge, but the

supply of zinc concentrates of sufficiently high grade is so limited that the plant could not operate economically, even if no special difficulties were met in smelting the leady zinc ores of British Columbia. Further, such a smelter would only be able to utilize a small fraction of the zinc ores that are waiting treatment, and it would seem more prudent to await the development, which cannot be far off, of a process that can handle the mixed ores as well as the high grade concentrates.

2. After reviewing and investigating a number of processes for the treatment of low grade and leady-zinc ores, it appears probable that one or more of these may shortly attain to commercial success. The Trail smelter, where investigations of this nature are now being made, would be a suitable place, in view of its location and present equipment, for treating the British Columbia zinc ores by such a process.

3. Encouragement should be given to any competent concern engaged in developing such a process, with a view to the production of zinc in Canada at the earliest possible time. In view of the large supplies of low grade and complex zinc ores in British Columbia and other parts of Canada, the smelting companies, such as the Consolidated Mining and Smelting Company, have already a strong inducement to work out a process for the treatment of these ores at the earliest possible time, but in view of the urgency of the situation and the high cost of operating in this country, it may be desirable to offer a bounty on zinc made in Canada, sufficient in amount to enable this metal to be produced in competition with zinc and zinc-products imported from the United States.

5. *APPENDICES TO THE REPORT.*

1. Supplies of zinc ores in British Columbia and other parts of Canada and the concentration processes in use.

2. Exports of zinc ores to smelters in the United States; prices paid, duties, freight and net returns to miners.

3. Canadian markets for zinc and zinc products.

4. Belgian zinc smelting:—
    1. Cost of zinc smelting in the United States.
    2. Locations for a smelter in Canada and cost of operations.

3. Size and capacity of zinc smelters.
4. The zinc smelter erected at Frank, Alberta.

5. Processes for smelting complex and low grade zinc ores.
   1. Distilling the ore in briquettes or in special retorts.
   2. Production of zinc fume in the blast furnace, on a Wetherill grate, or in a Dedolph or Fink furnace.
   3. Electric smelting of zinc ores.
   4. Sulphate and sulphite leaching processes, including those of Parnell, Létrange, French and Watts, and the bisulphite process.
   5. Chloride leaching processes; the Hoepfner process.
   6. Chlorine smelting process; Ashcroft and Swinburne.
   7. A comparison of these processes.

6. Zinc refining.

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5. *APPENDIX 1.*

SUPPLIES OF ZINC ORES IN CANADA AND THE CONCENTRATION PROCESSES IN USE.

Supplies of zinc in Canada may be divided into two parts. Firstly zinc ores and concentrates that are at present being shipped to the United States for treatment; these ores being limited in amount by the necessity of their containing a sufficiently high percentage of zinc, or of zinc and silver, to pay for the shipment. Secondly, the zinc ores and zinc-lead ores containing too little zinc or too much lead to permit of shipment to the United States, The amount of these ores is probably far more than that of the shipping ores, but at present they are of no value as they cannot be utilized.

The quantity and composition of the shipping ores can be fairly definitely stated and is indicated in Table I. Nearly the whole of these ores are obtained in British Columbia, and corresponding figures for this Province are given in Table 2. The small amount of ore that has been shipped from Ontario and Quebec is indicated in Table 1. The zinc ores in British Columbia are essentially by-products from lead mines, the ores being obtained either by hand-picking or as a product of dressing operations in which the lead concentrate is the main product of the operation. The only outlet for these ores has been to the zinc smelters in the United States with occasional shipments to Europe, and for this purpose only high grade ores can be employed; containing for example, over 40% of zinc in the case of low silver ores or over 30% of zinc in the case of ores containing some 30 ozs. per ton of silver. The average compositions of the shipping ores are indicated sufficiently closely by the figures in Table 1.

TABLE 1—ANNUAL PRODUCTION OF ZINC ORES IN CANADA.

Calendar Year	Zinc ore shipped, tons of 2000 lbs	Zinc in ore	Silver in ore, oz. per ton	Price of Zinc per lb. in New York	Price of Silver per oz. in New York	Spot value per ton in Canada
1910......	5,063	43.1%	21.0	5.520c	53.486c	$23.70
1911......	2,590	45.3%	39.0	5.758c	53.304c	$39.02
1912......	6,415	41.7%	27.2	6.943c	60,835c	$33.54
1913......	7,889	44.8%	18.2	5.648c	59.791c	$23.68
1914......	10,893	41.8%	34.6	5.213c	54.811c	$24.10

The zinc production of Canada is obtained almost entirely from British Columbia, the following being the only shipments from other parts of Canada reported during the five years.

Calendar Year	Province	Zinc ore Shipped	Zinc in ore	Silver in ore	Spot Value per ton.
1910..................	Ontario	576 tons	37%	....	$10.00
1911..................	....	0 "	....	....	....
1912..................	Ontario	10 "	50%	....	$37.50
1913..................	Quebec	335 "	47%	....	$20.00
1914..................	Quebec	969 "	36%	....	$10.35

TABLE 2.—ANNUAL PRODUCTION OF ZINC ORES IN BRITISH COLUMBIA.

Calendar Year	Zinc ore shipped, tons of 2000 lbs.	Zinc in ore	Silver in ore, oz. per ton	Price of Zinc per lb. in New York	Price of Silver per oz. in New York	Spot value per ton of the ore in Canada
1910......	4,487	43.9%	23.7	5,520c	53.486c	$25.45
1911......	2,590	45.3%	39.0	5.758c	53.304c	$39.00
1912......	6,405	41.7%	27.2	6.943c	60.835c	$33.00
1913......	7,554	44.7%	19.0	5,648c	59.791c	$23.85
1914......	9,924	42.3%	37.9	5.213c	54.811c	$25.45

The shipments of zinc ores from British Columbia in 1913 amounted to 7,554 tons of ore and concentrates containing about 45% of zinc. These shipments were all from mines in the Slocan and Ainsworth mining divisions. The principal shipping mines in 1913 being:—The Standard Mine, Silverton; The Van Roi Mine, Silverton; The Surprise Mine, Cody; The Rambler-Cariboo Mine,McGuigan; The Noble Five, Cody and the Lucky Jim, Ainsworth. Of these the Standard Mine alone contributed 4,443 tons of concentrates containing 43% of zinc. The Consolidated Mining and Smelting Company at Trail, considers that the mines in the Slocan and Ainsworth mining divisions could produce from 7,000-10,000 tons of zinc concentrates containing 40-45% of zinc and 20 ozs. or more of silver per ton, and 3,000 to 5,000 tons of zinc ore with low or negligible amounts of silver. The iron in these ores would be about 10% and the lead from 4-8%.

Taking these mines in detail, their capacity is estimated as follows:—

Standard Mine	4,000	tons.
Van Roi Mine	doubtful.	
Slocan Star Mine	1,000	"
Surprise Mine	1,500	"
Rambler-Cariboo Mine	1,000	"
Noble Five Mine, perhaps	200	"
Utica Mine, "	300	"
Hewitt Mine, "	2,000	"
Payne Mine (from ore in old workings)	500	"
Bluebell Mine, (ore of 40% zinc)	2,500	"
Lucky Jim Mine	1,000	"
Miscellaneous Mines	500-1,000	"

This list indicates that perhaps 10,000 tons of 45% concentrates might be obtained yearly from this section, and that if ores as low as 40% of zinc could be utilized an output of at least 15,000 tons might be expected. These outputs are estimated to last for at least two years, while an output of at least 10,000 tons of 40% zinc ore can be depended on for five years or an indefinite period.

The production of zinc ores in British Columbia in 1914 was 9,924 tons, all obtained from the Slocan and Ainsworth mining divisions. In January and February alone of 1915, the following shipments were made:—

Hewitt Mine	245	tons.
Rambler-Cariboo Mine	167	"
Surprise Mine	1,116	"
Utica Mine	85	"
Whitewater Mine	86	"

Or a total shipment from these five mines of 1,699 tons in two months.

In addition to the Slocan and Ainsworth mining divisions there is now a considerable production of low grade oxidised zinc ore from Ymir in the Nelson mining division. Some 3,000 to 5,000 tons of zinc ore containing about 30% of zinc and very little silver may be produced from the H.B. Mine, Sheep Creek, this production being safe for a period of two years, and probably for five years.

In East Kootenay, the Sullivan Mine and other properties can be depended on for the production of a very large tonnage of a low grade zinc-lead ore, if such ore could be profitably utilized, and this production could be depended on for a period of from 5 to 10 years.

Zinc ores have also been discovered in Northern British Columbia and the coast region, but while some of these are quite encouraging, they may be regarded in general only as possibilities for the present.

The British Columbia shipping ores consist in general: first, of handpicked ores containing from 40-50% of zinc and having some 10-12% of lead with variable amounts of silver; second, zinc concentrates obtained by a concentration process that yields:—(*a*) a lead concentrate, (*b*) a zinc concentrate and (*c*) tailings; the zinc concentrate containing some 30-45% of zinc, 2 or 3% of lead and variable amounts of silver.

The ore dressing processes employed are mainly of a simple type involving the use of jigs and tables. Magnetic separation was advocated by Mr.

Ingalls in his report, but has not been employed to any considerable extent. The tests of the Zinc Commission seem to show that a better separation of the zinc from the lead could be obtained by the use of a more careful ore dressing system, including magnetic concentration preceded by a roasting operation. The ore dressing tests made by the Commission showed that from many of the ores a concentrate running about 50% of zinc could be produced that would contain about 90% of the zinc in the original ore. This conclusion only applies to a limited number of the ores; others, notably the Sullivan ore, could not be advantageously concentrated.

Since the time of the report, flotation processes have been applied to the concentration of many ores, and it is probable that this process could be applied with advantage to some of the British Columbia ores. With this and

TABLE 3.—ANALYSES OF ZINC AND LEAD ORES AND CONCENTRATES FROM MINES IN BRITISH COLUMBIA.

	Zinc %	Lead %	Silver oz.	Gold oz.	Silica %	Iron %	Sulphur %
Zinc ores from—							
Aurora Mine	33	21.5	7.3	0.02	....	....	....
Aurora Mine	25	15	5	....	....	....	....
Blue Bell	14	13	4	....	....	....	....
Eastmount Mine	30	3	80	....	25	5	....
Eastmount Mine	20	10	215	....	41	5	14
Good enough Mine	45	11	22	0.02	....	....	....
Hartney Group Mine	27	8	23	....	....	....	....
Sullivan Mine	31	10	3	....	13	13	31
Zinc Concentrates from—							
Big Ledge Mine	19	trace	1	....	....	....	....
Emily Edith Mine	38	8	24	0.02	....	....	....
Enterprise Mine	44	5	115	....	....	....	....
Hewitt Mine	6	5	18	....	....	....	....
Hewitt Mine	33	11	80	0.03	....	....	....
Jackson Mine	35	1.4	5	0.02	....	....	....
Lucky Jim Mine	33	10	11	....	....	....	....
Monitor & Ajax Mine	34	4	14	....	....	....	....
Payne Mill	42	5	18	....	....	....	....
Ruth Mine	37	1.4	5	0.02	....	....	....
Ruth Mine	32	2.1	35	....	7.2	15	23
Slocan Star Mine	34	1.8	38	....	....	....	....
St. Eugene Mine	20	10	6	....	....	....	....
St. Eugene Mine	17	2	....	....	20	....	....
Lead ores and Concentrates—							
Emerald Mine	8	36	1	....	2	9	1
Enterprise Mine	20	30	108	....	15	6	6
Molly Gibson Mine	11.3	43	71	0.02	....	....	....
Standard Mine	7	70	80	....	4	....	13
Sullivan Mine	12	27	11	....	....	....	....
Sullivan Mine	15	20	....	....	15	18	19
Van Roi Mine	10	65	100	....	10	....	17

The above analyses are taken from the Zinc Commission Report and other sources and will serve to show the general character of the ores, but must not be taken as average analyses from the mines mentioned.

other improvements in the ore dressing operations, there is no doubt that cleaner products both of lead ores and of zinc ores could be obtained from many of the mines, but there will still remain a large class of ores, of which the Sullivan may be taken as a type, which cannot be separated into satisfactory ores either for lead smelting or for zinc smelting, and which await the development of a process for treating the ore as a whole for the recovery of the lead, zinc and silver contents. The accompanying Table 3, gives a number of analyses of ores and concentrates from the report of the Zinc Commission in 1906, and in part from other sources. The table will serve to give a general idea of the composition of the British Columbia ores, but must not be taken as indicating the average analyses of ores from the mines mentioned.

In addition to the British Columbia ores there are a few deposits of zinc ore in Eastern Canada. The most important of these is the mine at Notre Dame des Anges, in Quebec, from which shipments were made amounting to 335 tons in 1913 and 969 tons in 1914. The ore shipped is practically free from lead and silver, and contains nearly 40% of zinc.

APPENDIX II.

EXPORTS OF ZINC ORES TO UNITED STATES SMELTERS, PRICES PAID, DUTIES, FREIGHT AND NET RETURNS TO MINERS.

Exports of Zinc ores to United States Smelters.—Zinc ores mined in British Columbia have in general been supplied to zinc smelters in the United States. The amount of these shipments has been comparatively small, averaging 6,500 tons per annum during the last five years, but rising to 10,900 tons in 1914, and the monetary returns to the miners have also been small. This is due to the low grade of the ore; only a moderate quantity of concentrates being obtainable of a sufficiently high grade to pay for shipment.

Table 1, page 192, shows the amount of zinc ore and concentrates shipped from Canadian mines during each of the last five years, together with the average percentage of zinc and ounces of silver in the ores, market prices of zinc and silver, and average "spot value" of the ore. The silver contents reported must be somewhat too low as the reports were incomplete. The "spot value" of the ore is understood to be the price paid by the smelter less the freight and the United States import duty, but the figures given are probably incorrect.*

Prices Paid for Zinc Ores.—The scale of payments made by United States smelters for zinc concentrates is very complex and does not easily give a clear understanding of the charges made for smelting and marketing the zinc. The following example of prices paid by smelters in Oklahoma, for ores from British Columbia, will illustrate the usual rates.

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*The writer is indebted to John McLeish, B.A., of the Mines Branch, Ottawa, for the figures for 1914 and for the silver contents of the ores.

TABLE 4.—APPROXIMATE PRICES PAID BY THE UNITED STATES SMELTERS, AND NET RETURNS TO THE MINERS, FOR ZINC ORES OF VARYING CONTENTS OF ZINC AND SILVER.

Note.—The freight is taken at $10.00 per ton of ore carried, or $10.50 per ton of dry ore, and it is assumed that there is no duty to pay on account of lead in the ore, and no penalty for lime in the ore.

1. *Ores containing 5 ozs. of silver per ton, with zinc at 5c per lb.*

Zinc %	Smelter's Price	Duty on zinc	Net return to miner
45	$21.50	$ 1.10	$ 9.90
40	16.50	0.60	5.40
35	11.50	0.10	0.90

2. *Ores containing 5 ozs. of silver per ton with zinc at 6c per lb.*

Zinc %	Smelter's Price	Duty on zinc	Net return to miner
45	$28.50	$ 1.80	$16.20
40	22.50	1.20	10.80
35	17.50	0.70	6.30

3. *Ores containing 35 ozs. of silver per ton, with zinc at 5c per lb. and silver at 50c per oz.*

Zinc %	Smelter's Price	Duty on zinc	Net return to miner
45	$32.40	$ 1.45	$20.45
40	27.40	1.00	15.90
35	22.40	0.60	11.30
30	17.40	0.30	6.60

4. *Ores containing 35 ozs. of silver per ton with zinc at 6c per lb. and silver at 60c per oz.*

Zinc %	Smelter's Price	Duty on zinc	Net return to miner
45	$41.50	$ 2.10	$28.90
40	35.50	1.60	23.40
35	30.50	1.15	18.85
30	25.50	0.75	14.25

The ores are penalized $1.00 per unit for lime in excess of 1½%. The freight and United States import duty are paid by the miner.

Duties, Freight and Net Returns to Miners.—The freight from British Columbia to points in Oklahoma, payable by the miner, is about $10.00 per ton. The United States import duty is 10% of the value of the zinc contents of the ore. The value of the zinc in the ore is based upon the price paid by the smelter to whom it is consigned; deduction being made for the freight from mine to smelter. In general the value is taken as the price paid by the smelter on account of the zinc contents of the ore, less a part of the total freight that is

proportionate to the value of the zinc in relation to the whole value of the ore.

The amount of the United States duty, and the net return to the miner, after deducting the duty and the freight is given in Table 4 for a number of typical cases.

There is also a duty of ¾c per pound of lead in the ore, on ores containing over 3% of this metal; thus an ore containing 6% of lead would be charged 90c per ton. In this connection it must be remembered that the miner while paying a duty for the lead in the ore, is not paid anything for this metal by the zinc smelter.

In view of the above prices and deductions, it will be seen that an ore containing under 6 ozs. of silver per ton, must contain at least 40% of zinc, in order to afford any return to the miner, but when the silver amounts to 20 or 30 ozs. per ton, ores can be sold containing as little as 30% of zinc. These would be the minimum grades that would be saleable, and the poor returns from such ores, together with the limited amount of ore obtainable of even moderate grade, explain the small dimensions of the trade in zinc concentrates, and constitute a serious obstacle to the establishment in Canada of a zinc smelter of the ordinary type.

*Prohibition of Export of Zinc Ores.**—By an Order in Council of the 27th April, 1915, the export from Canada of zinc and zinc ore (including zinc ashes, spelter, spelter dross, and zinc sheets) is prohibited to all destinations abroad other than the United Kingdom, British Possessions and Protectorates. This prohibition went into effect on the 30th April, subject to the right of the Government to issue licenses for exportation in certain cases under guarantee to prevent the articles reaching the enemy. (A copy of the form of guarantee in general use is appended).

The standing of the consignee, however, is open to investigation in each case before the issue of the license. The prohibitory order cannot have had any effect on the shipment of zinc ores, as they are still being exported *under license* to the United States, as there are no smelters or refineries for zinc in Canada at present.

GUARANTEE.

To the Minister of Customs,
Ottawa, Canada.

In consideration of your consenting to the delivery to us of Zinc Ore we hereby give you the following undertaking, which will remain in force so long as the present war continues:

That no portion of the said zinc ore exported from Canada to the United States, and received by us, shall be disposed of, except for manufacturing purposes in the United States, and that no portion of the resulting product shall be exported to any destination from which it might either directly or indirectly reach any country at war with Great Britian.

....
Signature.

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*I am indebted to Mr. John McDougald, Commissioner of Customs, for information under this head.

APPENDIX III.

CANADIAN MARKETS FOR ZINC AND ZINC PRODUCTS.

In connection with the economic possibility of producing metallic zinc in Canada, the extent of the home market must be considered, as the products from a Canadian zinc smelter would need to be disposed of largely in this country—the United States markets being practically barred.

In 1906 Mr. W. R. Ingalls in considering the situation stated that the Ainsworth and Slocan districts could produce, when their milling capacity was somewhat increased, as much as 30,000 tons of 50% blende annually, so that a zinc smelter treating these ores in Canada should yield some 12,000 tons of spelter yearly. The Canadian consumption of spelter at that time was only about 3,000 tons, thus leaving a balance of 9,000 tons to be exported. At the present time the situation is quite different from this; the probable production of zinc in Canada, even supposing that a process for the treatment of the low grade ores is developed, would only amount to some 5,000 tons of metal, although no doubt the production would increase as the demand for these ores became well established. In the meantime the Canadian market has grown until about 8,000 tons of zinc are consumed yearly in Canada in addition to brass and zinc products which, as is shown in Table 7, would bring the total Canadian consumption of zinc up to 15,000 tons per annum.

All the zinc used in Canada prior to the war was imported from abroad, mostly from the United States, Germany, England and Belgium, so that the amount consumed can be satisfactorily determined from the Customs returns which are reported in Tables 5 and 6. It is clear from these tables that in the first place there is an ample market for any zinc production that can be expected in the near future, and further that the production of spelter in Canada, especially in conjunction with the proposed refining of copper in this country, will ultimately lead the way to a very large development in manufacturing metallurgy.

In Table 7 the weights and prices of zinc and zinc products, including brass, have been tabulated for the two fiscal years ending March 31st, 1913 and 1914. The amount of zinc contained in each item has been estimated and the totals obtained show a consumption of some 17,000 tons in 1913 and 15,000 tons in 1914. Complete returns for the year ending March 31st, 1915, were not available and these would be of little value in view of the disturbance of commerce caused by the war. On the other hand a large amount of zinc is now used in this country for the manufacture of ammunition and other military equipment, so that there is every reason for expediting in every way possible the production of zinc in Canada.

It may be mentioned that the ammunition at present contracted for by the Shell Committee will require some 28,000 tons of brass, representing 9,000 tons of zinc.

TABLE 5.—IMPORTS OF ZINC AND ZINC PRODUCTS.

From Reports of Department of Customs for Fiscal Year ending March 31st.

		1913.		1914.	
		Cwt.	$	Cwt.	$
Zinc in blocks, pigs bars rods, sheets and plates.......	United Kingdom..	6,363	38,563	3,996	24,468
	Bermuda.........	24	73	....	....
	Newfoundland and Labrador.......	3	6	....	....
	Belgium.........	22,012	141,327	19,900	111,716
	Germany.........	53,029	311,947	11,565	62,053
	Holland..........	2,448	15,494	....	....
	Miquelon and St. Pierre..........	25	45	....	....
	United States.....	15,407	109,683	10,313	72,788
	Total.........	99,311	617,138	45,774	271,025
Zinc spelter........	United Kingdom..	18,823	110,918	22,474	110,717
	Belgium..........	17,511	102,382	18,243	89,671
	Germany.........	6,495	38,488	9,683	46,364
	United States.....	65,016	378,776	62,712	330,497
	Holland..........	....	....	3,360	15,260
	Norway..........	....	....	900	6,429
	Total........	107,845	630,564	117,372	598,938
		Lbs.		Lbs.	
Zinc dust..........	Germany.........	126,588	7,835	34,287	1,863
	Holland.........	11,323	651	....	....
	United States.....	142,356	9,980	309,530	19,946
	United Kingdom..	....	....	600	58
	Belgium.........	....	....	13,160	686
	Total........	280,267	18,466	357,577	22,553
Zinc, sulphate and Chloride of......	United Kingdom..	659,717	17,697	90,637	1,876
	Belgium..........	66,437	1,809	83,272	1,379
	Germany.........	21,601	919	95,436	1,709
	United States.....	249,380	9,056	258,408	9,077
	France..........	....	....	1,544	25
		997,135	29,481	529,297	14,066
Zinc, manufactures of, N.O.P.......	United Kingdom..	....	2,353	....	2,157
	Belgium..........	....	291	....	....
	France..........	....	225	....	638
	Germany.........	....	182	....	319
	United States.....	....	51,467	....	46,302
	Aust.-Hungary....	....	....	....	81
	Total........	....	54,518	....	49,497
Zinc, white........	United Kingdom..	851,070	32,500	1,298,339	44,046
	Belgium..........	928,221	32,299	1,874,807	68,519
	France...........	33,700	1,286	47,750	2,066
	Germany.........	2,205,970	109,283	2,475,249	105,872
	Holland..........	429,591	15,641	717,452	27,775
	Italy............	42,240	1,160	....	....
	Switzerland.......	104,000	852	....	....
	United States.....	5,129,542	239,934	4,429,481	208,452
	Total........	9,724,334	432,955	10,843,078	456,730
Colours zinc white	United Kingdom..	1,350,900	32,025	1,598,698	46,101

TABLE 6.—IMPORTS OF BRASS.

From Reports of Department of Customs for Fiscal Year ending March 31st.

		1913.		1914.	
		Cwt.	$	Cwt.	$
Brass, old and scrap	United Kindgom..	502	7,256	138	2,088
	Bermuda.........	38	260	....	....
	B. Guiana........	66	664	25	226
	B. W. Indies......	61	357	4	27
	Newfoundland and Labrador.......	92	917	209	1,733
	Germany.........	93	1,634	....	....
	Miquelon and St. Pierre..........	18	127	....	....
	United States.....	43,617	542,190	24,980	291,667
	Denmark.........	....	....	2	24
	Total........	44,487	553,405	25,358	295,765
Brass in blocks, ingots and pigs....	United Kingdom..	102	2,172	....	....
	United States.....	19,820	292,526	17,663	232,831
	Germany.........	....	....	199	2,367
	Total........	19,922	294,698	17,862	235,198
Brass bars or rods..	United Kingdom..	1,183	20,795	804	13,461
	Germany.........	62	1.024	538	8,591
	United States.....	53,254	912,290	46,507	735,148
	Total........	54,499	934,109	47,849	757,200
		Lbs.		Lbs.	
Brass tubing.......	United Kingdom..	479,186	94,794	344,075	67,987
	Belgium..........	5,210	985	35,840	5,695
	Germany.........	148,499	26,667	139,242	29,923
	United States.....	1,621,989	348,747	1,436,659	313,836
	Holland..........	....	....	80	16
	Total........	2,254,884	471,193	1,995,896	417,457

	1915 (11 months)
Brass, old and scrap..	1,197,700 lbs.
Brass in blocks, ingots or pigs....................................	759,000 "
Brass tubing..	1,466,598 "
Brass bars or rods..	544,000 "
	3,967,298 "

TABLE 7.—SUMMARIZED IMPORTS OF ZINC AND ZINC PRODUCTS.

Zinc or Zinc Product.	Year ending Mar. 31, 1913			Year ending Mar. 31, 1914		
	Tons of Product	Price per lb.	Tons of Zinc	Tons of Product	Price per lb.	Tons of Zinc
Zinc in blocks, pigs, bars, rods, sheets and plates	4,965	6.2c	4,965	2,289	5.9c	2,289
Zinc spelter	5,392	5.8c	5,392	5,869	5.1c	5,869
Zinc dust	140	6.6c	126	179	6.3c	161
Zinc sulphate and chloride	499	2.9c	220	265	2.7c	116
Zinc white and colours	5,538	4.2c	4,400	6,221	4.0c	4,900
Brass old and scrap	2,224	12.3c	667	1,268	11.6c	380
Brass blocks, ingots and pigs	996	14.8c	299	893	13.2c	268
Brass tubing	1,127	20.9c	338	998	15.8c	299
Brass bars or rods	2,725	17.1c	817	2,392	15.8c	718
	....	....	17,224	....	....	15,000

7. *APPENDIX 4.*

THE BELGIAN SYSTEM OF ZINC SMELTING.

This is the standard method of obtaining zinc from its ores in the United States. The ore is first roasted very thoroughly for the removal of sulphur; it being necessary to leave not more than about 1% of this element. The roasted ore is then mixed with about half its weight of anthracite coal or coke, in the form of powder, the whole is dampened to avoid dusting, and is shovelled into a fire-clay retort heated in a furnace. The zinc oxide is reduced to metal by reaction with the carbon of the coal or coke; the metallic zinc leaves the retort as a vapour, and is condensed in a fire-clay condenser which has been attached to the open end of the retort. The operation of charging, distilling the zinc, and discharging the residues from the retort, occupies about twenty-four hours. The yield of the operation is about 80% of the zinc contained in the ore, the percentage recovery varying with the richness of the ore, being smaller with low grade ores.

The distilling furnace contains several hundred retorts, which are heated by coal fires, or preferably by means of producer gas or natural gas. Practically all the modern plants are operated by producer or natural gas. The type of furnace varies somewhat with the kind of fuel employed; producer gas furnaces being provided with regenerative chambers for preheating both the gas and the air that is used to burn it, while with natural gas the air only needs be preheated. On account of this, and the need of gas producers when natural gas is not available, the natural gas furnaces are considerably cheaper than those employing coal. The amount of coal used for the treatment of zinc ores is considerable, amounting to about two and a half tons per ton of zinc ore smelted, and it is therefore important to locate a zinc smelter near a source of cheap fuel. On account of the great expense of smelting zinc ores, the operation is hardly profitable for ores containing less than about 40% of zinc.

The residues left in the retorts after the distillation operation, contain practically all the silver and nearly all the lead of the original ore. These residues are sent to a lead smelter where they are smelted with other ores of lead for the production of a lead bullion carrying both the lead and silver.

Ores containing considerable proportions of lead or iron, are objectionable in the Belgian process because these materials tend to corrode the fire-clay retorts in which the operation is conducted; thus increasing the expense of the process. Lime in the ore is also harmful for the same reason.

COST OF ZINC SMELTING IN THE UNITED STATES.

The cost of smelting zinc ores by the Belgian method in the United States varies considerably at different smelters according to the nature and cost of the fuel available and the character of the plant. The cost of a zinc smelter has been given by Mr. W. R. Ingalls at about $10.00 per yearly ton of ore smelted, in the case of a plant employing natural gas, and about $16.00 per yearly ton of ore smelted when coal must be employed with regenerative gas firing. The following estimate of the cost of smelting zinc ores by natural gas in Kansas is given by Mr. W. R. Ingalls in the Zinc Commission Report, page 31.

The cost is given for smelting one ton of high grade zinc ore, using natural gas at 2c per thousand cubic feet, and the figures quoted amount to $8.00 per ton of ore treated. To this I have added a figure for interest and depreciation, estimated at 20% of $10.00 that is $2.00 per ton, making a total cost of $10.00 per ton of ore. If the ore contained 53% of zinc, it would yield, with an 84% extraction, 890 pounds of spelter; this would be worth, at 5c per pound, $44.50; the smelting cost is 22½% of this amount or 1.12c per pound of spelter.

COST OF SMELTING ONE TON OF ORE BY NATURAL GAS IN KANSAS.

Labour (2.125 man shifts at $2.00)	$ 4.25
*Fuel (natural gas at 2c) 40,000 cu.ft.	.80
Reduction material (coal 0.5 tons at $1.60)	.80
Clay for retort making, etc., (1/10 ton at $4.40)	.44
Supplies (miscellaneous)	.20
Repairs and renewals	.48
Administration	1.00
	$ 8.00
Interest and depreciation (20% of $10.00)	2.00
Total cost per ton of ore	$ 10.00

**Note on Gas Consumption.*—Mr. W. R. Ingalls in the Mineral Industry, Volume 16, states that the consumption of natural gas for distilling zinc ores has been found to vary from 40-50 thousand cubic feet per ton of raw ore, or 48-60 thousand cubic feet per ton of roasted ore. In addition to this, the roasting of the ore would need 4,500 cubic feet of gas in a well designed roaster, while many roasters now in use consume as much as 30,000 to 40,000 cubic feet of gas. This indicates that with natural gas at 2c per thousand, the cost

When natural gas is not available, and coal is used for heating, the cost is somewhat higher on account of the greater cost of the plant, the larger amount of labour needed and the higher cost of coal fuel. The following table shows the cost of smelting one ton of high-grade zinc ore at a modern plant in the United States, using coal at $1.50 in gas producers and with regenerative gas-firing. The plant would cost $16.00 for each ton of ore smelted per annum. Interest and depreciation at 16% of this is $2.56. The data are taken from W. R. Ingalls' Metallurgy of Zinc, page 602, and the Zinc Commission Report, 1906, page 31.

COST OF SMELTING ONE TON OF ZINC ORE WITH COAL FOR FUEL, AT A MODERN PLANT IN THE UNITED STATES.

$2\frac{3}{8}$ men for one day at $2.00	$ 4.75
$2\frac{1}{2}$ tons of coal at $1.50	3.75
$\frac{1}{8}$ ton of clay at $4.00	0.50
Repairs, renewals and supplies	0.80
Administration	1.10
	$ 10.90
Interest and depreciation at 16% on $16.00	2.56
Total cost per ton of ore	$ 13.46

Note.—The cost at the present time would be higher than this owing to increased cost of labour and fuel.

LOCATIONS FOR A ZINC SMELTER IN CANADA AND COST OF OPERATION.

A zinc smelter to operate at a profit in Canada would have to be located at a point where cheap fuel was available. It is also desirable that labour and supplies should be obtained at moderate rates; that the freight charges from the mine to the smelter should be as low as possible; that the residues from the zinc smelter should be returned easily to a lead smelter for treatment, and that the freight charges from the zinc smelter to the market should be as low as possible.

It does not appear possible to find any place that entirely meets these requirements. A few may be considered:—

1. *A point in or near the Crows Nest Pass, using coal directly from the mines.*—The following estimate has been made of the cost of smelting one ton of zinc ore at such a centre; the data were taken initially from the Zinc Commission Report, page 54, but the prices of labour and fuel have been altered in view of local conditions. A plant in the United States, using coal, would cost about $16.00 per yearly ton of ore, and a plant in Canada is estimated to cost 25% more than this, or $20.00 per yearly ton.

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for the fuel may be considerably higher than given in the table. An investigation of the cost of fuel gas to American zinc smelters in the year 1906 showed the average cost to be about 1.8c per thousand cubic feet.

COST OF SMELTING ONE TON OF ORE NEAR CROWS NEST PASS.

Labour, $2\frac{1}{2}$ men for one day at \$3.50	\$ 8.75
Fuel, and reduction material, $2\frac{1}{2}$ tons of coal at \$2.00	5.00
Retort making, etc., $\frac{1}{8}$ ton of fire-clay at \$8.00	1.00
Supplies miscellaneous	.25
Repairs and renewals	1.00
Administration	1.00
	\$ 17.00
Interest and depreciation 16% on \$20.00	3.20
	\$ 20.20
Freight on ore to Crows Nest Pass	2.50
Freight on spelter to market $\frac{1}{3}$ ton at \$10.00	3.30
	\$ 26.00
Value of 1 ton of 45% zinc ore, Recovery at 80%, 720 lbs. at 5c per lb.	\$ 36.00
Cost of mining and dressing ore, say	2.00
Balance left for profit of miner and smelter	\$ 8.00

The present practice of selling the ore in the United States leaves a clear return to the miner of \$9.00 per ton after paying the United States duty of \$1.10, the freight charge of \$10.00 and the United States Smelter's profit.

It will be seen that the cost of smelting under these conditions would be about twice that of smelting with gas in the United States, and that there would be scarcely any profit available for the smelter and the miner; the return for the miner would be less than by the present practice of shipping to the United States.

An alternative scheme would be to place the smelter at some point in the Crows Nest Pass where coke is being made; to replace the present beehive ovens by modern ovens of the recovery type, and to use the surplus coal gas for operating the zinc smelter. It would appear that such a plant could be operated at a considerable saving on the above estimate.

2. *At Medicine Hat, or similar locality, where natural gas is available.*—It would appear to be better to ship ore to some such point, rather than to smelt by means of coal in the Crows Nest Pass, provided of course that the supply of natural gas were found to be sufficiently large to last for a reasonable length of time. I have been informed that natural gas could be obtained by a zinc smelter in Medicine Hat, for as little as 2c per thousand cubic feet, provided the company operating the smelter were to drill their own gas wells. The following estimate will give an idea of the cost of smelting under these conditions, and the profit available from the treatment of one ton of ore. The cost of the plant is taken at \$12.00 per yearly ton of ore, and interest and depreciation at 20% of this amount.

COST OF SMELTING ONE TON OF ORE BY NATURAL GAS IN CANADA.

Labour	$ 7.00
Reduction material (½ ton at $3.00)	1.50
Fuel (natural gas at 2c)	1.00
Clay	1.00
Supplies	.25
Repairs and renewals	1.00
Administration	1.50
	$ 12.75
Interest and depreciation	2.40
Total cost of smelting 1 ton of ore	$ 15.15
Freight on ore from mines to smelter	3.00
Mining the ore	2.00
Freight to market at $10.00 per ton of spelter	3.00
Cost of producing and marketing the spelter from one ton of ore	$ 23.15
Value of zinc in a 45% ore:—900 lbs, Recovery 80%—720 lbs. at 5c	$ 36.00
Profit for miner and smelter	$ 12.85

The net return to the miner for selling this ore in the United States would be $9.00 per ton.

In the case of a smelter at Medicine Hat, the ore would incur a freight charge of some $3.00 per ton from the mine to the smelter, and it would also be necessary to carry the retort residues from Medicine Hat back to some point like Trail, where they could be smelted for the recovery of the lead and silver values. The amount of such residue would be about 70% of the original ore, and the freight might be about $4.00 per ton, corresponding to about $3.00 per ton of the original ore.

Size and Capacity of Zinc Smelters.—A zinc smelting plant, in order to be operated economically, would need to be of such a size as to treat at least 25,000 tons of ore yearly; such a plant costing some $500,000 if coal were used in gas producers, or somewhat less if natural gas were available. A plant of this capacity would be somewhat too small for obtaining the utmost economy of operation, while on the other hand, it would require about twice as much high grade zinc ore as is at present available in Canada. On this account alone, it appears inadvisable to undertake the erection of a Belgian zinc smelter in this country.

The Frank Zinc Smelter.—About the year 1904 a smelting plant was erected at Frank, Alberta, by some French capitalists. The plant was badly designed, both in respect to the furnaces themselves and to the provisions for the economical handling of ore, materials and products. The

operations were not successful; only two carloads of spelter were produced, and these probably cost from 10c to 20c per pound. The plant was designed for five furnace blocks containing 240 retorts each, and it would have had a smelting capacity of 13,000 tons of 45% ore per annum. It was impossible to obtain sufficient ore for the whole plant, and only two of the five furnaces were finished and operated. The retorts were made at the smelter, using a mixture of equal parts of local clay and fire-clay from St. Louis. Coal was obtained from a mine owned by the operators and located close to the plant. The cost of the coal was about $1.75 per ton, but the quality was much worse than had been anticipated; the ash amounting to about 20%. The coal was used in Taylor gas producers. Ordinary labour cost $2.75 per shift, and skilled labour about $4.50 per shift. The skilled labour for the furnace construction and operation was brought from Kansas by the works superintendent, and the large amount and high cost of this labour was one element to the failure of the plant. The ore was ferruginous, and when the furnaces were heated sufficiently to distil the zinc, the retorts became slagged by the iron in the ore. The failure of this enterprise may be put down to the following items:—

1. High labour charges and too large a staff.
2. Poor quality of coal.
3. Insufficient supply and low grade of ore.
4. Faulty design of furnace blocks.
5. Faulty design of the Merton roasters used.

APPENDIX 5.

PROCESSES FOR SMELTING COMPLEX ZINC ORES.

Ores containing notable proportions of both zinc and lead are of little value to either the zinc smelter or the lead smelter. In the ordinary zinc distilling process, lead in the ore corrodes the retort, and in addition, necessarily lowers the content of zinc in the ore and renders it too low grade for economical treatment. Similarly, if the ore is smelted for lead, the zinc is very harmful, as it interferes with the operation of the lead furnaces. In smelting these ores by the zinc process, the silver and most of the lead can be obtained by resmelting the residues. In smelting the ores by the lead process, the zinc contents are entirely wasted.

The need has been felt, for many years, of a process for treating these ores in such a way as to recover the zinc, lead and silver, both efficiently and economically. Many processes have been devised, and some have been used commercially, but none of these is in commercial use on any large scale.

I. DISTILLING THE ORE IN BRIQUETTES OR IN SPECIAL RETORTS.

These are modifications of the distillation process that are applicable to zinc ores containing too much lead to be treated by the ordinary methods. Messrs. Picard and Sulman devised a process which was tried at the Emu

works in Wales where upwards of 4,000 tons of ore were treated by it during the year 1901, and it has later been tried at Cockle Creek, New South Wales.

The process consists of mixing the roasted ore with about 20% of its weight of crushed coking coal; briquetting the mixture with about 5% of pitch, and distilling the zinc from the briquettes in retorts in the ordinary manner. The lead and silver are retained as metallic particles in the coherent residues of the briquettes, and therefore the lead does not corrode the retorts. It is also found that the spelter obtained is satisfactorily free from lead; the spelter averaging 99% of zinc and only 0.5% of lead, when obtained from ore containing 25% of zinc and 24% of lead. The opinion has been expressed that the satisfactory results obtained are due rather to the use of pitch in the charge, than to the briquetting of the ore. It should also be added that the retorts cannot have been heated very strongly, as the residues retained 5% to 8% of zinc and only 70% of the zinc in the ore was recovered. The retorts lasted on an average from 35 to 42 days.

Another method of treating these ores by the Belgian process depends on the use of a special refractory retort. Benjamin Sadtler, of Denver, has invented a refractory lining, for the zinc retort, which consists of a layer, $\frac{1}{8}$ of an inch thick, of some basic material such as magnesia or chromite applied, with a solution of silicate of soda, to the interior of the retort. Retorts prepared in this manner will serve to distil the zinc from leady or irony ores without suffering excessive corrosion, and have been in regular use for treating the leady ores of the Western States.

II. PRODUCTION OF ZINC FUME IN THE BLAST FURNACE, ON THE WETHERILL GRATE, OR IN A DEDOLPH, OR FINK FURNACE.

Zinc ores cannot be smelted in the blast furnace, like ores of iron or lead for example, because the metal zinc is extremely volatile and its vapour is so easily oxidized. Even carbon dioxide or water vapour is sufficient to oxidize the zinc vapour and so prevent it becoming condensed in the metallic form. On account of its extreme volatility it is comparatively easy to expel the zinc from the ore, in a state of vapour, which can then be condensed in the form of an oxidized fume. The Wetherill process consists in mixing the roasted zinc ore with anthracitic coal, and charging the mixture upon a bed of burning coal on a special grate supplied with a forced blast. The zinc oxide is reduced to the metallic state, vaporized, and then reoxidized, forming a smoke of zinc oxide which passes away with the furnace gases, and after cooling to a low enough temperature is collected by filtration through muslin bags. Any ore dust carried mechanically from the furnace is allowed to settle from the gases before they reach the filter-bags, and in this way a clean white fume is obtained which constitutes a valuable paint.

The process is used in New Jersey and Pennsylvania for the production of zinc oxide from certain low grade ores which could not economically be converted into zinc by the ordinary process. Tests made upon the British Columbia ores with this process, show that a portion of the silver in the ore is carried over with the fume, and on this account it would not be possible to use the Wetherill process for the production of zinc white from argentiferous zinc-lead ores, as any silver in the fume would be wasted. The lead in the ore

is carried over quite as completely as the zinc and the resulting leady-zinc fume forms a satisfactory paint.

In view of the fact that some 6,000 tons of zinc white, costing over 4c. per pound, is imported annually into Canada it would be probably worth while to establish here a Wetherill plant for the treatment of the zinc and zinc-lead ores that are sufficiently low in silver to be treated by this process. Such ores would amount to at least 5,000 tons per annum, containing from 35% to 40% of zinc and capable of producing over 2,000 tons of zinc white for which there would be an ample market.

The Wetherill process requires at least one ton of fuel for each ton of ore treated, and although this would not be an excessive charge on the production of a saleable paint, it prohibits the use of this process as a concentration operation for the production of a lead-zinc fume, containing silver, which must be later treated by some electric furnace or other process for the recovery of the contained metals.

There appears to be no essential reason for this large consumption of fuel, when it is merely required to volatilize the zinc without regard to the colour of the resulting fume, and for the recovery of zinc from low grade ores free from gold, silver and copper, it would be worth while to experiment with a modified form of the Wetherill furnace arranged for continuous operation and with a greater depth of charge. Such a furnace should serve to remove the zinc as a fume from a 30% roasted ore with a consumption of some 30% of its weight of anthracite or coke; the residue being melted to a clinker and removed mechanically from the furnace. It is important to bear in mind that such a process could not well be applied to the treatment of finely divided materials such as concentrates produced by flotation or similar means; as the blast would carry a large portion of the finely divided ore out of the furnace in the form of dust. For the treatment of complex ores containing zinc, lead, silver and copper there are several processes depending on the same general principle by which the lead and zinc contents of an ore may be separated as a metallic fume at a reasonable cost.

The F. L. Bartlett Process for the treatment of complex lead-zinc sulphides consists of two operations. In the first, the raw sulphide ore containing over 20% of zinc, is crushed, mixed with 15% to 20% of small coal, and charged on to the perforated grate of the Bartlett "blowing-up" furnace. Nearly all the lead and part of the zinc is volatilized and recovered as a fume, leaving a clinker containing about 8% of sulphur, 15% of zinc, 1% of copper and less than 1% of lead with nearly all the gold and silver of the ore. This clinker, with additional low grade sulphide ores of zinc, lead and copper is smelted in a low blast furnace, with 6% to 15% of coke, yielding a copper matte containing the gold and silver, and a fume containing the lead and zinc. The slag from this operation retains from 3% to 15% of zinc oxide. The Bartlett process has been in use at Canon City, Colorado and at Portland, Me.; further particulars will be found in Hofman's Metallurgy of Lead.

The Ellershausen Process has been tried in Wales and on a large scale at Angouleme in France. The ore, containing sulphides of zinc, lead and iron, with some silver, gold and copper is smelted raw in a blast furnace yielding a fume, a matte and a slag. The fume contains all the lead, nearly all the zinc and about 50% of the silver of the ore, while the matte carries the copper, gold

and the remainder of the silver. The furnace gases pass into towers where the fume is collected by a spray of water. The zinc is largely present as soluble zinc sulphate and can be separated by filtration from the lead and silver which remains as sulphides. The complete separation of these metals is effected by a somewhat complicated treatment with caustic soda. The zinc is ultimately recovered as oxide and the lead and silver as lead bullion. The process is no longer in use.

Some recent attempts to solve the same problem have been made by Edward Dedolph, who employs a furnace shaped like a Brückner Roaster, the ore being fed in at one end and a flame of burning oil entering at the other. The zinc is reduced and volatilized with part of the lead, and the residue is available for smelting in a lead furnace. No information is available with regard to the application of this process on a large scale, but tests are being made in the smelter at Trail.

The Fink Furnace is essentially a basic copper converter, arranged for continuous or intermittent rotation, and provided with three or four lines of tuyeres. Its main function is the combined smelting and bessemerizing of sulphide copper ores, but it can also be employed for volatilizing the zinc and lead from a complex sulphide ore, containing these metals and copper. The raw ores are smelted in the Fink furnace so as to form a copper matte and to volatilize most of the lead and zinc; nearly all the lead and about 60% of the zinc is volatilized during the smelting operation, and the copper matte serves to collect any gold or silver that may be present in the ore. The copper matte is then bessemerized in the same furnace while the remaining zinc is nearly all driven off; an elimination of more than 90% of the zinc being obtained. Up to the present it has been found necessary to use an oil flame for heating the converter, and to mix a portion of fuel with the ore to insure the volatilization of the zinc.

Mr. Fink informs me that the amount of fuel required for smelting in his furnace will vary with the variety of ore treated, but should in no case exceed 35 U.S. gallons of fuel oil, or an equivalent amount of coal, per ton of ore charge. He States that in a recent test with Burma ore, containing 18% lead, 35% zinc, 0.5% copper and 0.75% cobalt, he used 28 U.S. gallons of fuel oil for smelting each ton of ore, and 50 lbs. of coal for eliminating the zinc during the bessemerizing period. In that test all the lead and 93% of the zinc were volatilized.

Mr. Fink has worked out a process for recovering the zinc and lead from the fume obtained in the converting furnace. This is by the use of a vertical retort made of basic refractory material and arranged for the continuous distillation of zinc from the oxides of zinc and lead. These oxides fume are mixed with crushed coke or coal, and are fed into the top of the retort after being heated to remove gases as far as possible. An excess of coke is employed so that the metallic lead, formed by reduction of the lead oxide, is held as shots in the powdery coke, and the residue is discharged at intervals from the bottom of the retort. The zinc in the charge is distilled and passes continuously into a lateral condenser. The zinc retorts are large enough to treat 1,000 lbs. of material per day, and the charging and discharging are carried out mechanically, so that the labour required should be only one third of that needed for the standard Belgian process. The fuel used for heating the retorts is expected

to be 30% to 40% less than in the Belgian zinc furnace. Full details of this process are not at present available, but the information at hand appears favourable to the success of the process.

Other methods for the treatment of lead-zinc fume, when this contains silver and is therefore too valuable to be sold as a paint, would be by smelting the fume in an electric furnace, obtaining metallic zinc and a lead bullion, or by treating the fume in some electrolytic process such as that of Mr. Watts, to be described later.

III. ELECTRIC SMELTING OF ZINC ORES.

In the ordinary Belgian process for distilling zinc from its ore, the operation is carried out in retorts made of fire-clay. These are necessarily small in size—about eight inches in diameter and four feet long—because the heat must be transmitted from the burning fuel through the wall of the retort to heat up the charge of zinc and coal. This is essential because zinc is so easily oxidized that the flame of the burning fuel cannot be allowed to come in contact with the zinc ore charge. Electrical heating has always appeared to be ideal for the distillation of zinc ores, because it can be applied within the mass of ore without the necessity of introducing any oxidizing gases as would be the case if fuel were used for heating. In this way the use of the small zinc retort is rendered unnecessary, and zinc ores can be smelted in furnaces of a considerable size. Electrical heat is of course more expensive than heat produced by the combustion of fuel, but the use of fuel for heating the ore in the ordinary Belgian process is so inefficient that it will frequently be possible to replace it to advantage by heat, provided by electrical energy, that can be produced within the mass of ore and therefore far more efficiently.

As long ago as 1900 I had begun to look into the possibility of using electrical energy for smelting complex zinc ores, so as to obtain at one operation metallic zinc and a lead bullion containing silver, and shortly after coming to McGill University I carried out some experiments with one of my students, Mr. L. B. Reynolds, on the smelting of British Columbia ores in an electric furnace. The experiments were successful as far as the recovery of the metals, zinc, lead and silver were concerned, but we were confronted by the difficulty of obtaining the zinc in the molten form; the whole of that metal being condensed as a metallic powder which could not be caused to run together into the molten condition. On this account the experiments were discontinued.

Shortly after this, Mr. F. T. Snyder of Chicago, carried out a number of experiments on a somewhat larger scale in the same direction, and devised and patented quite a number of furnaces for the electrical smelting of zinc ores. With the assistance of the British Columbia Government, he put up about the year 1908, a smelter at Nelson, British Columbia, for the electric smelting of the British Columbia zinc-lead ores. This smelter included a large mechanical furnace for roasting the ores, and an electric furnace for smelting the roasted ore and distilling the zinc. Apparently Mr Snyder had not overcome the inherent difficulty of the process, and he was unable to obtain successful results with his smelter. His work was therefore given up, and the British Columbia Government took over the smelter in view of the money they had advanced towards its equipment.

In the year 1910 an investigation into the electric smelting of zinc ores was started in my laboratory at McGill University under instructions from Dr. Eugene Haanel, Director, Mines Branch, Ottawa, and with Mr. W. R. Ingalls as technical adviser.

When zinc ores are smelted in an electric furnace the zinc vapour produced condenses largely as a fine metallic dust known as "blue powder" instead of forming molten spelter that can be poured into moulds. A large number of experiments were made to investigate the phenomenon, and althought the causes were fairly well ascertained we were not able to remove them entirely and to obtain a satisfactory condensation of the metal. In the meantime Mr. W. McA. Johnson, of Hartford, Connecticut, has spent a great deal of time, money and energy, in attacking the same problems, and apparently he has had a reasonable measure of success. His work has, however, been carried out behind closed doors, and full information has not been given in regard to the details of the furnace and operation, and the results obtained.

The electric smelting of zinc ores has been tried by various experimenters in Europe and the Laval process has been in commercial operation for some years at Trollhattan in Sweden. The practice there is not materially in advance of the experiments already described, and is only possible in view of very cheap electric power and other local conditions. In regard to the use of the electric furnace for smelting the lead-zinc ores of British Columbia, it may be stated in conclusion that it should be possible to smelt these ores economically with the recovery of a satisfactory proportion of the zinc, lead, silver, gold and copper contents, but that owing to the difficulty experienced in condensing the zinc to molten metal, the writer is of the opinion that this cannot be done by any electric furnace now in use. It is still possible that this difficulty may be overcome in one way or another and that electric smelting may become a commercial process for the treatment of these ores.

IV. SULPHATE AND SULPHITE LEACHING PROCESSES, INCLUDING THOSE OF PARNELL, LETRANGE, FRENCH AND WATTS.

The processes described in sections 1, 2 and 3 of this appendix have been furnace methods involving the fusion of the ore, or at least the reduction of zinc oxide by means of carbon at high temperature, and the volatilization of the metallic zinc. There are a large number of processes in which furnace methods for smelting the ores or reducing the zinc at high tenperatures are not employed. In these processes the essential operation is the treatment of the ore with some aqueous chemical reagent for the purpose of dissolving the zinc from the ore; leaving undissolved the lead, gold and silver and the gangue of the ore. Such processes can be used to remove the zinc from a complex zinc, lead, and silver ore, obtaining the zinc in a solution from which it can be recovered, and leaving the lead and silver, freed from the zinc, and suitable for smelting by ordinary methods. In the absence of lead the zinc and the silver could be recovered separately from the ore by appropriate chemical treatments.

These processes can be divided into:—

(*a*) The formation of zinc sulphate, using sulphuric acid as a solvent usually after a sulphatizing roast.

(*b*) The formation of zinc sulphite using sulphurous acid as solvent, after an oxidizing roast.

(*c*) The formation of zinc chloride, using hydrochloric acid as solvent, usually after a chloridizing roast.

(*d*) The solution of zinc by means of ammonium compounds.

After obtaining the zinc in solution by any of these methods it can be recovered either by precipitation as an oxide or similar compound, which needs further treatment to produce metallic zinc, or the metal can be obtained at once by electrolysis of the sulphate or chloride solutions. The sulphate and sulphite processes are closely allied and will be considered in this section.

Sulphate Processes.—Ores containing zinc sulphide (blende or sphalerite) are roasted at a low temperature so as to form zinc sulphate which is soluble in water. It is impossible to obtain all the zinc in a soluble condition, as an insoluble basic sulphate is always formed before the whole of the zinc sulphide is acted on; hence in the leaching operation sulphuric acid as well as water must be added to effect the solution of the zinc. Iron will also be dissolved to some extent thus rendering the solution impure. Any copper in the ore and some of the silver will enter the zinc solution. For the recovery of zinc from its oxide ores (calamine, etc.) a larger proportion of sulphuric acid would be needed. The solution of zinc sulphate, after purification, can be evaporated and the zinc sulphate crystallized out. There is a certain demand for this salt as a mordant in dyeing, as a preservative and in the manufacture of lithophone, some 300 tons of sulphate and chloride of zinc being imported annually into Canada, but for the production of metallic zinc the sulphate must be converted to oxide and smelted in the usual way, or, what is probably cheaper, the sulphate solution can be electrolysed using insoluble anodes for the production of spelter.

The Parnell Process was in use in South Wales a few years ago. The ore, which contained from 15-35% of zinc and 3-10% of lead was roasted at a low temperature in a muffle furnace for the formation of zinc sulphate. It was then treated in lead pans with sulphuric acid which dissolved the zinc and copper, leaving the iron, lead and gangue insoluble. The solution was treated with iron to remove the copper and was then evaporated until the zinc sulphate became pastey. Finely crushed zinc blende was then added and the mixture dried and heated in a muffle furnace, when the following reaction took place:—

$$3\ ZnO.SO_3 + ZnS = 4\ ZnO + 4SO_2$$

The resulting oxide of zinc was treated by the Belgian process and the SO_2 used to make sulphuric acid for treating fresh quantities of the ore.

The Letrange Process was tested on a large scale at St. Denis in France, about the year 1880. The ore (blende) was roasted with the ultimate formation of sulphates and oxide of zinc. The roasted ore was treated with water and with the acid solution obtained by electrolysis. The zinc sulphate solution was transferred to electrolytic tanks where it was electrolysed using insoluble carbon anodes and brass or zinc cathodes. The solution thus became poorer in zinc and richer in sulphuric acid and was returned to the leaching tanks to dissolve more zinc from the roasted ore. The deposited zinc when it became about 1/6 inch in thickness could be stripped off the cathode by means

of a knife. It was found, however, to contain iron which had been dissolved from the ore. Details about the current density, voltage, purification of the solution and character of the deposit are not available.

Substantially the same process is now being tried at Trail, but the general improvement that has taken place during the last ten or twenty years in crushing machinery, roasting furnaces and leaching apparatus may enable the present investigators to obtain better results and at a less cost than when the original process was tried. Lead sheets will now be used as anodes instead of carbon plates, as lead has been found to be a better anode material for use in sulphate solutions, while carbon is preferred in chlorides. At Trail the residue from the leaching operation contains lead and silver and will be smelted for these metals.

The French Process differs from the Letrange process only in the use of "nitre cake" (acid sulphate of soda) instead of sulphuric acid for dissolving the zinc from the roasted ore, and in having in the electrolyte a small amount of a manganese salt which is said to prevent polarization and deterioration of the anode. Nitre cake is a by-product from the manufacture of nitric and hydrochloric acids; it can be obtained in Victoria at $5.00 per ton from the chemical works. The following account of the process was given me by Mr. Thomas French, the son of the inventor.

The ore is crushed to 30 mesh and roasted in a Wedge roaster to a mixture of sulphate and oxide of zinc, the roasting being regulated in view of the amount of sulphuric acid required. The roasted ore is treated with a solution of nitre cake containing about 17% of the acid sulphate, $NaHSO_4$; this is equal to 10% of the normal sulphate, Na_2SO_4 in the neutral solution. The solution also contains some manganese sulphate, equal to at least 0.1% of manganese. The acid sulphate reacts with zinc oxide in the ore to form normal sulphate of soda and zinc sulphate, according to the equation:—

$$2\,NaHSO_4 + ZnO = Na_2SO_4 + ZnSO_4 + H_2O$$

The amount of zinc taken up as sulphate varies from 5% to 10% of the solution and is usually about 7%. The solution is treated with the roasted ore until it becomes neutral. In this way any iron is precipitated, leaving a clean solution for electrolysis. The extraction of the zinc is carried out at about 53° C., the operation being conducted by means of agitation, settling and filter press, but some ores can be leached in the ordinary manner. In the experimental work the extraction has been effected by agitation and decantation. The operation is carried out in two or more stages, so that the solution is neutralized with fresh ore before it is used for electrolysis, and the partially exhausted ore is thoroughly extracted with fresh acid solution. In the case of an ore containing 24% of lead and 24% of zinc, an amount of zinc equal to 2·7% of the original weight of the ore will remain in the residue, giving an extraction of 89%. After leaving the leaching apparatus, the solution passes through a purifier containing sheets of zinc which serve to precipitate any impurities it may contain. The solution then enters the electrolytic tanks which contain lead anode 1/12″ thick and zinc cathodes. Electrolysis serves to deposit zinc on the cathode and liberates sulphuric acid and oxygen at the anode, the sodium sulphate helping to carry the current.

The oxygen formed at the anode oxidises the manganese sulphate to sodium permanganate and this liberates manganese dioxide which falls to the bottom of the tank as a mud. The formation of manganese dioxide serves to lessen the polarizing action caused by the formation of oxygen at the anode, and to prevent the deterioration, by oxidation, of the lead anodes. The manganese dioxide is returned to the leaching vats where it serves to clean the solution.

Electrolysis is carried out hot, the temperature of the solution rising to 40° C. before it leaves the tanks. Electrolysis is continued until the solution contains only 1% of zinc and as much as 6% of free sulphuric acid. A current density of 10 to 20 amperes per square foot is employed; requiring, with a neutral solution, a voltage of 3.8 to 4.2. The neutral solution requires about 4 volts and yields about 1.2 grammes of zinc per ampere hour (the theory is 1.21 gram.) while an acid solution will only yield about 1.1 gram per ampere hour. As, however, the acid solution needs only 3 volts, on account of its greater conductivity, the ultimate efficiency is greater. Moreover the zinc deposited from an acid solution is better and more metallic in appearance.

The process is supposed to be dependent for its efficiency on the presence of sodium sulphate and manganese sulphate in the electrolyte, these substances having the effect of preventing deterioration of the anode and of enabling the zinc to be obtained with a smaller power consumption. The process requires on an average about 3000 k.w. hours per ton of zinc; that is, 1·5 k.w. hours per pound.

The following estimate of cost for producing one ton of zinc was given by Mr. French. The ore contained 24% of zinc, 24% of lead, and 20 ounces of silver per ton; 80% of the zinc is supposed to be extracted.

Cost of producing one ton of zinc by the French Process.—

6¼ tons of ore at $3.00	$ 18.75
Grinding and roasting the ore, including labour	12.00
3600 k.w. hours and motor and dynamo losses, say 4000 k.w. hours at $20.00 h.p. year = 0.306c per k.w. hr.	12.25
Labour and fuel	24.00
Loss of chemicals	1.50
Freight and marketing from British Columbia to England	20.00
Depreciation, etc.	6.50
	$ 95.00

Assets per ton of zinc.—

3.12 tons of residue at 48% lead at $9.00 per ton	$ 28.00
2000 lbs. zinc at 5c per lb.	100.00
20 ozs. silver × 6¼ = 125 ozs., less 5% = 118·75 ozs. at 50c =	59.35
	$ 187.35
Cost as above	95.00
Profit	$ 92.35

The cost of production per ton of ore	$95.00	÷ 6¼ = $15.20
Profit per ton of ore	$92.35	÷ 6¼ = $14.75

The cost of a plant for producing 100 tons of zinc per day and thus treating 625 tons of ore daily would be about $1,000,000. Cost of plant per yearly ton of ore treated would be about $5.00.

THE PRODUCTION OF ZINC BY ELECTROLYSIS OF SULPHATE SOLUTION.

To produce metallic zinc by the electrolysis of zinc sulphate is not at all easy. If we start with a slightly acid solution of zinc sulphate with an insoluble anode and a metallic cathode, electrolysis will deposit zinc on the cathode and will liberate SO_4 at the anode. The SO_4 combines with water forming H_2SO_4 and liberates oxygen which tends to attack the anode. As the action proceeds the electrolyte becomes poorer in zinc and richer in sulphuric acid which tends to redissolve the zinc that has deposited on the cathode. Meanwhile the deposit of zinc which was smooth at the beginning has become rough and striated due to the liberation of hydrogen bubbles on its surface and may even become black and spongy. This poor deposit is unable to resist the attack of the increasingly acid solution, and after a time the deposition of zinc practically stops. Many investigators have found, even if a zinc anode is used so that the electrolyte remains rich in zinc and low in acid, that they could not produce a thick deposit of coherent zinc; the deposited metal becoming unsatisfactory after a few hours of electrolysis. The presence of basic zinc salts appears to be one cause of trouble and the growth of zinc trees is another, as the metal deposits rapidly on these projecting points and the rate of deposit on the rest of the plate becomes too small, resulting in the formation of spongy zinc. When insoluble anodes are used (as is necessary when we wish to obtain the metal from its compound) the conditions become rapidly worse, as the solution becomes poorer in zinc and at the same time it becomes richer in acid.

In spite of the difficulties which undoubtedly attend the production of electrolytic zinc, several workers are now able to obtain satisfactory deposits and to continue these for perhaps six days, so that we may consider that these difficulties have been overcome to a reasonable extent.

It may be stated in a general way that the solutions should contain about 5-10 grams of zinc per 100 c.c. of solution with perhaps 0.1 gram of free sulphuric acid; other salts such as sodium or ammonium sulphate added to the solution are favourable as they increase the conductivity, and certain organic additions, notably colloids, assist in producing a smooth deposit. The electrolysis may be carried out cold, but a slight rise of temperature appears to be beneficial both in regard to the economy of the operation (by increasing the conductivity) and in respect to the smoothness of the deposit. The current density usually employed is about 10 amperes per square foot and this needs about 4 volts with insoluble anodes.

The next difficulty is in regard to the nature of the anodes. Anodes of Acheson graphite are found to answer well in chloride solutions, but they disintegrate when used in sulphate solutions, and lead anodes have usually been employed. The lead becomes peroxidized on the surface, and the scale of oxide tends to become detached, thus exposing the lead to further attacks. Lead plates will last a considerable time, however, and they may be made to

last still longer by using them at first in an alkaline electrolyte which has the effect of forming a more adherent coat of oxide.

The same difficulty has been experienced in working out methods for the recovery of copper from its ore by electrolysis of copper sulphate, and it has been overcome by the use of magnetite electrodes. These are made by melting magnetite in an electric furnace and casting it around a wire net. Another successful anode is made by depositing lead peroxide electrolytically on carbon rods. It seems probable that magnetite electrodes can be used to advantage for the electrolysis of zinc sulphate. Even after the electrolysis is finished, a heavy loss, even 20% to 25%, may be experienced in melting the deposited zinc after this has been stripped from the cathode plates. A better method appears to be to dip the electrode into molten zinc covered with a flux, whereby the loss can be kept down to about 3% of the weight of the deposit.

Professor J. W. Richards* points out that it is easy to misunderstand and misuse the process of obtaining zinc sulphate from an ore and recovering the zinc by electrolysis. In roasting the ore it is usual to try to make as much sulphuric acid as possible so as to form the soluble zinc sulphate, and then during electrolysis the sulphuric acid is liberated and causes increasing difficulty. It would be more logical, he says, to roast the ore to zinc oxide and to use this for neutralizing the acid formed during electrolysis. He suggests the use of two-compartment cells with thin diaphragms, passing the zinc bearing solution through the cathode compartments first, where zinc is deposited from a slightly acid solution; next through the anode compartments, where the solution becomes strongly acid, and then through the ore-leaching tanks, where the acid is neutralized in dissolving fresh amounts of zinc oxide.

This principle has been utilized in the Siemens-Halske processes for treating ores of copper and of zinc, and in a simplified form in the Watts process for zinc ores; the oxidized ore being placed in the anode compartment of the electrolytic cell where it is directly acted on by sulphuric acid liberated at the anode.

The Bisulphite Process depends on the fact that zinc oxide will dissolve in a solution of SO_2 forming the bisulphite $ZnH_2(SO_3)_2$ and that on expelling the excess of SO_2 the zinc is precipitated as the normal sulphite $ZnSO_3$.

These reactions have been known for some time and were employed by the late Dr. Karl Höepfner to extract zinc from its ores, but he converted the sulphite to chloride and electrolysed that with insoluble anodes, obtaining metallic zinc and chlorine. The method employed at present is to roast the sulphite precipitate to oxide which is then reduced to zinc by the ordinary Belgian method.

The Bisulphite process is being operated at Llansamlet in Wales by the British Metals Extraction Company, who claim an extraction of 90% of the zinc from a 30% ore; thus leaving a residue with less than 8% of zinc. The cost of operating is not stated, but the reagent used, sulphurous acid, is obtained directly from the gases produced in roasting the ore and there is no cost for materials except for fuel for roasting and for power. On the other hand the process does not produce metallic zinc, but only an oxide to be worked up by other methods.

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*J. W. Richards, Trans. Amer. Electrochem. Soc., Vol. XXV. page 288.

The Watts Process.—Mr. E. E. Watts, M.Sc., a recent student of Queen's University has done some very careful work with the intention of developing a process for treating the complex Sullivan ore. He studied the effect of roasting the ore at different temperatures, and leached the roasted ore with water, sulphuric acid and sulphurous acid; finding that the latter produced the best extraction. For this treatment with SO_2 moreover the ore could be roasted at a higher temperature than if zinc sulphate were to be formed, thus obtaining a quicker roast and leaving the iron of the ore in a less soluble condition. The ore employed contained:—

31.2% Zinc.	13.4% Iron.
10.1% Lead	12.8% Silica.
31.0% Sulphur.	3.2% Alumina.
3.1 ozs. Silver.	trace Lime.

The roasting was started at 650° or 700° C. and was continued up to 850° C. and the ore was then ground to pass an 80 mesh sieve before leaching. The extraction of the zinc, after a leach of 45 minutes with SO_2 solution, was 87% and the residue contained 16% of lead and under 8% of zinc and could therefore be smelted for lead.

The zinc sulphite precipitate is usually roasted to oxide and treated by the Belgian process, but as this is not in use in Canada, Mr. Watts tried to produce the metal by electrolysis of the bisulphite solution. No satisfactory deposit could be obtained from this or from a solution of zinc sulphate to which the sulphite precipitate was added. He found, however, that a good deposit could be obtained by using a zinc sulphate solution and periodically adding zinc oxide, obtained by roasting the sulphite precipitate. In later work he enclosed the insoluble (lead) anodes in a muslin or canvas bag and added the oxide in this bag. With this arrangement satisfactory deposits of electrolytic zinc can be obtained using a current of about 10 amperes per square foot and needing about 4 volts to maintain this current.

Mr. Watts has extended his process to the treatment of zinc oxide made by the Wetherill process and to high grade zinc ores that have been roasted and finely crushed. In the treatment of ores there will be a considerable residue in the anode compartments and means must be devised for removing this mechanically.

The essential principle in the Watts process is the production of zinc by electrolysis of the sulphate which is kept up to strength by zinc oxide added in a porous compartment containing the insoluble anode. The oxide produced may be a roasted ore or may be obtained by the Wetherill or the Bisulphite process. The Watts process differs from the Letrange or the French processes in combining the electrolytic and the leaching vats into one; a principle which has been used for other metals such as copper, but not before for zinc.

Mr. Watts has carried out some of his later tests in my laboratory and, while I am not at liberty to give full details of his work, I can say that the process appears to me to be very promising, and will probably be put to a commercial test in the near future.

V. CHLORIDE PROCESSES INCLUDING THE HÖEPFNER PROCESS.

In the preceding section the separation of zinc from its ores was effected by sulphuric or sulphurous acid, both of which can be obtained from the gases produced in roasting the sulphide ores of zinc. Other processes have been devised in which zinc chloride is produced instead of zinc sulphate or sulphite. Such processes involve the use of hydrochloric acid to dissolve the zinc from an oxide or roasted ore, or the production of hydrochloric acid by roasting the ore with common salt. Such processes must therefore be more costly than those in which no such reagent is needed, but the electrolytic chloride methods produce chlorine as a by-product without extra expense. The amount of zinc deposited per ampere hour from a chloride solution is just the same as from a sulphate solution and the voltage required is also about the same.

An early process was that of Maxwell Lyte, who proposed to treat a complex ore by hydrochloric acid so as to dissolve both the zinc and the lead as chlorides. The solution is passed over metallic zinc which serves to precipitate the lead in the metallic state and the zinc is precipitated as oxide by means of lime.

The Höepfner Process.—Höepfner established and operated plants in Germany, England and Austria for recovering zinc from zinciferous pyrites cinders containing about 10% of that metal. This material was roasted with common salt so that the zinc, which was mostly as ZnS, reacted with the sodium chloride to form zinc chloride and sodium sulphate. These salts were leached out of the ore and the sulphate of soda was recovered by cooling the solution. The remaining solution was oxidized by bleaching powder and the impurities removed by precipitation first by calcium carbonate and then by zinc dust. The purified solution was electrolysed, using carbon anodes and a diaphragm between the anode and the cathode, with the production of metallic zinc and chlorine.

The Höepfner process has the advantage of producing chlorine and sodium sulphate as by-products in addition to the zinc, but the process was very complicated and it has been abandoned in favour of simpler processes.

VI. EXTRACTION OF ZINC FROM ITS ORES BY MEANS OF AMMONIUM COMPOUNDS.

Proposals have been made to extract zinc from its ores by means of ammonia or ammonium compounds. The best solvent appears to be a solution of ammonium carbonate containing 7% or 8% each of ammonia and of carbonic acid. Zinc can be precipitated from this solution as a basic carbonate by distilling off the ammonia and the excess of carbonic acid. The method is too costly for the extraction of zinc from poor ores and need not be considered further.

VII. CHLORINE SMELTING: THE SWINBURNE AND ASHCROFT CHLORINE SMELTING PROCESS.

This is a method for the treatment of mixed sulphide ores such as those of zinc and lead. The ore, consisting of sulphides of lead, zinc, iron, and manganese, with some silver, is decomposed by the action of dry chlorine at

a temperature of 600° C., or 700° C., in a special vessel called a transformer, forming a fused mixture of chlorides of the metals. The sulphur comes off in the free state, and can be condensed and saved, while the earthy matter or gangue, from the ore, remains suspended in the fused chlorides. Enough heat is produced by the reaction to keep the transformer at the right temperature, which can be regulated by passing the chlorine more or less rapidly. When the vessel is full of chlorides they are tapped out, leaving enough behind to serve as a molten bath into which more ore can be charged, and through which the chlorine can be passed. The molten chlorides are treated with lead, which serves to remove the silver, and with zinc to remove the lead. The remaining chlorides are dissolved in water, separated from the gangue by filtration, and the iron and manganese precipitated chemically by the addition of chlorine and zinc oxide, leaving a solution of zinc chloride only. This solution is evaporated, and then fused and electrolyzed. The products are molten zinc, which is tapped off at intervals, and chlorine, which is compressed and used again for the treatment of fresh quantities of ore. The process is one of great interest, and is applicable to very many complex ores which are difficult to treat by other methods. It is self-contained, and does not require any expensive reagents, as the chlorine for the transformer is produced in the electrolysis of the zinc chloride, but the operations are somewhat complicated, and would need very careful attention. The only commercial installation is at a plant of the Castner-Kellner Co., which has a supply of chlorine from other processes, and uses it for the treatment of complex ores as described above, but omits the final electrolysis obtaining the zinc in the form of chloride.

VIII. A COMPARISON OF THE PROCESSES AVAILABLE FOR THE PRODUCTION OF ZINC FROM COMPLEX AND LOW GRADE ORES.

After having given a description of a number of the processes that have been tried for this purpose it may be possible to learn something by attempting a comparison between them. In the first place these processes may be classified in respect to the effect they produce.

1. *Processes that serve to recover zinc from the ores, but leave it in an oxidized condition.*

The Wetherill and similar processes do this; producing an oxide of zinc or a lead-zinc oxide.

The bisulphite process obtains the same result, except that in the case of a complex ore the zinc only is removed and converted into oxide, while the lead remains with the gangue and can be smelted separately.

The Parnell process produces the same results as the bisulphite, but it is more costly in operation and has therefore been superceded.

2. *Processes that produce metallic zinc from the low grade and complex ores.*

The Letrange and French processes and possibly the Watts process accomplish this, leaving the lead with the gangue to be smelted separately.

The modified Belgian methods of Picard and Sulman and of Sadtler also produce metallic zinc and leave the lead for subsequent smelting.

Electric smelting produces metallic zinc and also metallic lead at one operation.

3. *Processes that convert zinc oxide, made under head 1, into metallic spelter.*

The ordinary Belgian process.

The Watts process (using oxide in the anode compartment).

The electric furnace.

In view of the fact that most of these processes are still in the experimental stage it is well to compare them in view of the purpose each can effect, coupled with any essential elements of cost or efficiency of which we have knowledge, rather than to put much stress upon the degree of success that has already been attained.

Under heading 1 we have to compare the furnace method of producing zinc oxide or zinc-lead oxide with the chemical bisulphite process.

Material treated.—Sulphide ores of zinc or zinc and lead should be roasted to oxides before treatment by the Wetherill or bisulphite processes. The Wetherill requires a coarsely crushed ore while the bisulphite needs it in a fine powder.

Requirements:—The Wetherill process uses 1 ton of coal per ton of ore treated but it seems reasonable to suppose that one-third of this would be sufficient under more favourable conditions. The bisulphite process employs sulphurous acid which is produced in roasting the ore. The other elements of cost are not well known, but it seems probable that the bisulphite process will cost less, per ton of ore, than the Wetherill.

Results obtained.—The Wetherill process removes all the lead, 85-90% of the zinc and about half the silver and delivers them in a fume of nearly pure oxides of zinc and lead. The bisulphite process separates about 90% of the zinc as a sulphite precipitate which must be roasted to oxide and leaves the lead and silver in the residue. This residue would need agglomerating before it could be smelted for lead.

Application.—For a low grade zinc ore free from lead and silver either method could be used except that a finely divided concentrate would be unsuitable for the Wetherill process. For an ore containing zinc, lead and silver, the bisulphite process would be the more suitable as it produces two clean products; zinc oxide and a silver-lead residue for smelting. On the whole it appears as if the bisulphite process were better suited than the Wetherill to the treatment of the average complex ores such as are found in British Columbia. These ores could be dressed carefully to remove the gangue without attempting to separate the lead and zinc, and the galena-blende concentrates could be roasted and treated by the bisulphite process so as to produce a pure zinc oxide and a smelting silver-lead ore. the zinc oxide could easily be turned into spelter by the Watts process.

Under heading 2 we have three kinds of process to compare. The distillation processes of Picard and Sulman, and of Sadtler are suitable for ores that are rich in zinc but have too much lead and iron for the ordinary process. The operating cost and losses of zinc become rapidly higher, per pound of spelter, as the percentage of zinc in the ore decreases. For ores low in zinc it is probable that the electrolytic processes would be more economical, because one important element of cost, the power consumption, is proportional to the amount of zinc produced, while in the distillation processes the amount of fuel and the other elements of expense depend mainly on the amount of ore

to be treated. The electric furnace has the advantage of producing metallic lead as well as metallic zinc, but the disadvantage (at present) of yielding the zinc mostly as a powder. With very cheap power it might be profitable to smelt a complex ore mainly for a silver-lead bullion, obtaining as a by-product a metallic zinc fume that could be worked up by electrolysis, by fusion under a flux, or by a second distillation in the electric furnace. Considering the electrolytic processes, both the Letrange and French processes should serve to produce metallic zinc and a smelting lead ore economically from the complex ores. The Watts process may possibly prove suitable for the direct treatment of ores. Comparing some elements of cost in these processes. The electrolytic processes are mostly dependent on the cost of electrical power. If this costs $20.00 per h.p. year, the cost per k.w. hour will be 0·306c. The power consumption per pound of zinc made will be about 2 k.w. hours, or allowing for losses 0·7c. For treating a 30% ore, yielding 600 lbs. of zinc, the cost will be $4.20 per ton. Smelting the same ore in the electric furnace, the power consumption would be about 2100 k.w. hours including the redistillation of the blue powder. This at 0·306c is $6.42, or allowing for stand-by losses, say $7.00 per ton. The electric smelting produces lead bullion and may therefore be credited with the cost of smelting, say, 0·6 ton of lead residue at $5.00 that is $3.00, leaving a net power cost of $4.00 for the zinc in the ore. In other words the cost of electric smelting, allowing for resmelting the blue powder, is decidedly higher than the cost of an electrolytic process, but taking into account the fact that a lead bullion is produced by the electric furnace and not by the other method, there is not much difference in essential costs between the two processes.

Under heading 3. The three processes can all make good spelter from the pure oxide. The Belgian process would use, say, 2 tons of coal for fuel per ton of ore, costing at $2.00 per ton of coal, $4.00 per ton of ore. The Watts process costs, say, 0·7c for power per lb. of zinc, or $10.00 per ton of ore. The electric furnace uses, say, 2500 k.w. hours per ton of ore, costing 0·3c per k.w. hour, or $7.50 per ton of ore. The Watts process might save 5-10% more zinc than the other processes, say, 100 lbs. which at 5c would be worth $5.00 per ton of ore. This would make it as economical as the Belgian process and more so than electric smelting. At higher prices of spelter there would be still more advantage in a process that has a high recovery of metal.

Generally. There still remain for consideration the combinations of processes under heads 1 and 3 as compared with a single process under head 2. Thus we may treat an ore by the bisulphite process and work up the zinc oxide from that by the Watts process, or we may treat the ore directly by the French process or in the electric furnace. Such comparison would be very lengthy and enough has perhaps been said already in view of the limited data at our disposal.

APPENDIX VI.

THE REFINING OF ZINC

Nearly all the metals in ordinary use need refining to render them sufficiently pure for many of the purposes to which they are to be applied. Thus pig iron is refined by blowing air through it in the Bessemer converter—producing

steel; copper, lead and tin are also refined by exposing them to air, in the molten condition, whereby the impurities, which are more easily oxidized than the metal that is being refined, are removed as oxides in the form of a slag.

The metal zinc, however, is far more easily oxidized than the other metals and consequently cannot be freed from its impurities by any system of oxidation. The method of refining usually employed for zinc is to keep it molten at a low temperature in order to allow the separation by liquation of the admixed metals such as lead and iron; this method does not serve to produce a very pure grade of spelter and is merely useful for improving the more impure varieties.

Pure zinc can be produced by electrolysis, as in the case of copper, or by redistillation, but these methods are very little used except for the production of chemically pure zinc for use by chemists. The spelter obtained by the distillation of the purer varieties of zinc ore is freer from impurities than zinc that has been refined by the ordinary process, and is used for all commercial purposes, such as the manufacture of brass for cartridge making, where a pure zinc is essential.

Commercial spelter contains 98 to 99·96% of zinc; a trace to 1·8% of lead; 0·01 to 0·08% of iron; a trace to 0·8% of cadmium, and occasionally small quantities of arsenic, antimony, copper, silica, sulphur and carbon. High grade American spelters, such as the well known Bertha spelter, contain only 0·01 to 0·02% of lead and 0·01 to 0·02% of iron. American prime Western spelter contains 0·4 to 1·0% of lead and 0·02 to 0·05% of iron.

The American Society for testing Materials has adopted the following classification of the grades of spelter; the figures representing the maximum percentage of impurities allowable.

Grade	Lead	Iron	Cadmium	Total impurities
High Grade..........	0·07%	0·03%	0·05%	0·10%
Intermediate.........	0·20%	0·03%	0·50%	0·50%
Brass Special.........	0·75%	0·04%	0·75%	1·20%
Prime Western........	1·50%	0·08%	......	......

Zinc refining is not practised in the United States, but in Europe the liquation process is used in some localities for the treatment of spelters that are rich in lead and iron. The metal is melted in a reverberatory furnace and kept at a temperature just above its melting point. The lead, in excess of about 1%, tends to separate by gravity from the zinc, forming a layer in the bottom of the furnace, while the iron separates in a mushy layer between the lead and the zinc. Dross caused by oxidation of the zinc is skimmed off the surface and the purified zinc can be ladled out of the furnace from time to time, making up the quantity with fresh additions of crude spelter. The lead and iron are allowed to accumulate in the furnace until they are sufficient in amount to be worth removing. Molten zinc retains from 1·0 to 1·5% of lead even when cooled to its melting temperature, and it is not possible by this process to refine the zinc below about 1·2% of lead. The furnace holds about 30 tons of metal and treats 9 to 10 tons per 24 hours. The consumption of coal is about 8 to 10% and the loss of zinc by drossing about 1·5%. The separated lead retains over 1% of zinc.

Electrolytic refining of zinc is seldom employed to any considerable extent. The operation is substantially the same as in copper refining using a slightly acid solution of zinc sulphate and alkaline sulphates with cast anodes of impure spelter and cathodes of sheet zinc or sheet copper. The current density would be 10 to 15 amperes per square foot, that is the same as in copper refining, but the voltage required would be from 0·5 to 1·0 volt, or about twice as much as in copper refining. The power consumption per pound of metal would also be about twice as great. Electrolytic zinc refining is far more difficult to carry out than is copper refining, and there is less need for it as the best grades of spelter are pure enough for any purpose while the poorer grades can be used in other ways.

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6. *STATISTICS OF ZINC AND ZINC PRODUCTS IN CANADA.*

ZINC

The production of zinc ore in Canada in 1913, as obtained by direct returns from producers, was 7,889 tons, valued at $180,827, the greater part being from British Columbia. The zinc content of these shipments was returned as 7,069,800 lbs., which if valued at the average New York price of spelter during the year, 5.648 cents, would be worth $399,302.

The ore shipped from British Columbia contains also a varying silver content, for which payment is made by the smelters, and without which, on account of the import duty to the United States and the long rail haul, it would not in many cases pay to ship.

The British Columbia shipments were heavy as a result of the activity of the Slocan mines and mills. There were also shipments from Notre Dame des Anges, Portneuf county, Quebec.

During the year the new United States customs tariff came into effect, considerably reducing the duties payable on Canadian ores, the new items affecting Canadian shipments being:—

Zinc ores containing 25 per cent. or more zinc; 10 per cent. on zinc contained therein.

Lead-bearing ore: $\frac{3}{4}$ cent per pound on lead contained therein.

Although not paid for by the United States smelters, the lead in ore is considered dutiable and as there is often a small lead content in the zinc ore or concentrates shipped, the lead duty applies. The result of the decreased duties has been a considerable increase in zinc shipments.

During 1913 there were received at American smelting works from Canadian mines 7,074 tons of zinc concentrates, containing 5,941,727 pounds of zinc.

In 1912 these works reported the receipt of 7,190 tons containing 6,392,983 pounds of zinc.

The imports of zinc, taken as an index of consumption, show a fairly steady increase. The total imports of zinc in blocks, pigs and spelter, were in 1880 some 744 tons; in 1889 they had risen to 1,427 tons and remained fairly stationary the next ten years. In 1899 they were 1,213 tons and rose to 4,110 for the fiscal year 1909.

During the calendar year 1913 the imports were 8,664 tons of zinc, in addition to which there were 6,341 tons of zinc white, zinc manufactures to the value of $54,898, 206 tons of zinc dust, valued at $26,403; and 317 tons of sulphate and chloride of zinc, valued at $17,424.

Statistics of the production and imports of zinc, and the average monthly prices of spelter on the New York and London markets, are given in the following tables:—

ANNUAL PRODUCTION OF ZINC.

Calendar Year	Zinc ore shipped		Metallic zinc in ore shipped	
	Tons	Spot value	Lbs.	Final value
		$	$	$
1898	1,162	11,000	788,000	36,011
1899	865	18,165	814,000	46,805
1900	261	4,810	212,000	9,342
1901	....	....	....	....
1902	158	1,659	142,200	6,882
1903	1,000	10,500	900,000	48,660
1904	597	3,700	477,568	24,256
1905	9,413	139,200	*	*
1906	1,154	23,800	*	*
1907	1,573	49,100	*	*
1908	452	3,215	*	*
1909(†)	18,371	242,699	16,468,204	906,245
1910	5,063	120,003	4,361,712	240,766
1911	2,590	101,072	2,346,849	135,132
1912	6,415	215,149	5,354,700	371,777
1913	7,889	186,827	7,069,800	399,302
1914	10,893	262,563	9,101,460	474,459

*Figures not available.

†Includes 7, 424 tons shipped late in 1908.

IMPORTS OF ZINC IN BLOCKS, PIGS, AND SHEETS.

Fiscal Year	Cwt.	Value	Fiscal Year	Cwt.	Value	Fiscal Year	Cwt.	Value
		$			$			$
1880........	13,805	67,881	1892.....	21,881	127,302	1904.....	25,553	138,057
1881........	20,920	94,015	1893.....	26,446	124,360	1905.....	25,141	141,514
1882........	15,021	76,631	1894.....	20,774	90,680	1906.....	24,462	158,438
1883........	22,765	94,799	1895.....	15,061	63,373	1907 (9 m)	18,427	126,221
1884........	18,945	77,373	1896.....	20,223	80,784	1908.....	30,362	191,081
1885........	20,954	70,598	1897.....	11,946	57,754	1909.....	26,222	141,066
1886........	23,146	85,599	1898.....	35,148	112,785	Cal'der yr.		
1887........	26,142	98,557	1899.....	18,785	107,477	1910.....	31,660	191,051
1888........	16,407	65,827	1900.....	28,748	156,167	1911.....	33,678	206,859
1889........	19,782	83,935	1901.....	20,527	103,457	1912.....	100,095	617,836
1890........	18,236	92,530	1902.....	34,871	141,560	1913.....	47,226	291,368
1891........	17,984	105,023	1903.....	26,646	142,827	1914.....	31,609	189,785

IMPORTS OF SPELTER.*

Fiscal Year	Cwt.	Value	Fiscal Year	Cwt.	Value	Fiscal Year	Cwt.	Value
		$			$			$
1880........	1,073	5,301	1892.....	13,909	62,550	1904.....	33,952	164,751
1881........	2,904	12,276	1893.....	10,721	49,822	1905.....	37,941	206,244
1882........	1,654	7,779	1894.....	8,423	35,615	1906.....	50,137	290,686
1883........	1,274	5,196	1895.....	9,249	30,245	1907 (9 ms	42,465	269,044
1884........	2,239	10,417	1896.....	10,897	40,548	1908.....	65,593	314,369
1885........	3,325	10,875	1897.....	8,342	32,826	1909.....	55,981	310,688
1886........	5,432	18,238	1898.....	2,794	13,561	Cal'dar yr.		
1887........	6,908	25,007	1899.....	5,450	29,687	1910.....	109,084	561,170
1888........	7,772	29,762	1900.....	5,836	29,416	1911.....	116,996	654,097
1889........	8,750	37,403	1901.....	14,621	58,288	1912.....	117,845	686,585
1890........	14,570	71,122	1902.....	18,356	80,757	1913.....	126,051	661,207
1891........	6,249	31,459	1903.....	23,159	110,817	1914.....	108,454	551,031

IMPORTS OF ZINC, MANUFACTURES OF.

Fiscal Year	Value	Fiscal Year	Value	Fiscal Year	Value
	$		$		$
1880............	8,327	1892............	7,563	1904............	12,682
1881............	20,178	1893............	7,464	1905............	11,912
1882............	15,526	1894............	6,193	1906............	12,917
1883............	22,599	1895............	5,581	1907 (9 mos.).....	12,556
1884............	11,952	1986............	6,290	1908............	19,240
1885............	9,459	1897............	5,145	1909............	15,621
1886............	7,345	1898............	10,503	Calendar Year.	
1887............	6,567	1899............	14,661	1910............	21,829
1888............	7,402	1900............	11,475	1911............	30,862
1889............	7,233	1901............	6,882	1912............	46,336
1890............	6,472	1902............	6,683	1913............	54,898
1891............	7,178	1903............	9,754	1914............	36,355

*Spelter in blocks and pigs.

IMPORTS OF ZINC, OTHER PRODUCTS OF.

Calendar Year	Zinc white		Zinc dust		Zinc sulphate and chloride	
	Pounds	Value	Pounds	Value	Pounds	Value
		$		$		$
1910	8,496,399	312,779	97,461	4,859	237,466	6,470
1911	8,537,498	314,194	86,242	5,718	414,500	15,930
1912	10,505,944	425,714	308,239	18,944	941,780	29,104
1913	12,682,126	525,643	412,294	26,403	634,634	17,424
1914	9,445,397	389,796	362,109	34,295	352,715	9,390

WORLD'S PRODUCTION OF SPELTER IN SHORT TONS.*

Country	1908	1909	1910	1911	1912	1913
Australia	1,198	....	560	1,904	2,531	4,105
Austria and Italy	14,063	13,931	14,666	18,602	21,609	23,856
Belgium	181,851	184,194	190,233	215,050	220,678	217,941
France and Spain	61,512	61,859	65,191	70,791	79,543	78,293
Germany	239,062	242,594	251,046	276,008	298,794	311,914
Great Britain	60,029	65,422	69.531	73,803	63,086	65,201
Holland	19,017	21,548	23,121	25,059	26,380	26,813
Poland	9,740	8,758	9,514	10.952	9,659	9,520
United States	210,424	255,760	269,184	286,526	338,806	346,676
Norway	....	....	....	7,363	8,959	19,040
Total	796,896	854,066	893,046	986,058	1,070,045	1,103,359

WORLD'S CONSUMPTION OF SPELTER IN SHORT TONS.*

Country	1908	1909	1910	1911	1912	1913
Austria-Hungary	35,935	36,155	37,258	47,950	51,588	44.533
Belgium	74,956	71,209	84,326	81,240	85,098	84,216
France	85,869	73,744	62,059	90,389	90,389	89,286
Germany	198,634	207,343	203,374	241,734	248,899	255,734
Great Britain	152,669	171,408	195,989	193,674	204,146	214,508
Holland	4,189	4,409	4,409	4,409	4,409	4,409
Italy	9,259	9,039	8,929	11,133	11,795	12,015
Russia	19,621	20,282	27,447	31,856	30,754	36,707
Spain	5,512	4,960	4,630	5,291	5,181	6,503
United States	214,167	270,730	245,884	280,059	340,372	295,370
Other countries	11,023	9,921	13,669	19,621	21,715	23,038
Total	811,834	879,200	887,974	1,007,356	1,094,346	1,066,319

*Mineral Resources of the United States.

AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN NEW YORK.*

Month	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
Jan...	4.865	4.863	6.190	6.487	6.732	4.513	5.141	6.101	5.452	6.442	6.931	5.262
Feb...	5.043	4.916	6.139	6.075	6.814	4.785	4.889	5.569	5.518	6.499	6.239	5.377
Mar..	5.349	5.057	6.067	6.209	6.837	4.665	4.757	5.637	5.563	6.626	6.078	5.250
Apr...	5.550	5.219	5.817	6.087	6.687	4.645	4.965	5.439	5.399	6.633	5.641	5.113
May..	5.639	5.031	5.434	5.997	6.441	4.608	5.124	5.191	5.348	6.679	5.406	5.074
June..	5.697	4.760	5.190	6.096	6.419	4.543	5.402	5.128	5.520	6.877	5.124	5.000
July..	5.662	4.873	5.396	6.006	6.072	4.485	5.402	5.152	5.695	7.116	5.278	4.920
Aug..	5.725	4.866	5.706	6.027	5.701	4.702	5.729	5.279	5.953	7.028	5.658	5.568
Sept..	5.686	5.046	5.887	6.216	5.236	4.769	5.796	5.514	5.869	7.454	5.694	5.380
Oct....	5.510	5.181	6.087	6.222	5.430	4.801	6.199	5.628	6.102	7.426	5.340	4.909
Nov...	5.038	5.513	6.145	6.375	4.925	5.059	6.381	5.976	6.380	7.371	5.229	5.112
Dec...	4.731	5.872	6.522	6.593	4.254	5.137	6.249	5.624	6.301	7.162	5.154	5.592
Year.	5.40	5.100	5.822	6.198	5.962	4.726	5.503	5.520	5.758	6.943	5.648	5.213

AVERAGE PRICES OF SPELTER, ORDINARY BRANDS, IN LONDON.†

Month	1904			1905			1906			1907			1908		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
January......	21	11	2	24	19	9	28	8	2	27	7	1	20	6	3
February.....	21	16	5	24	10	6	26	2	4	26	1	5	21	0	7
March.......	21	19	6	23	13	6	24	15	3	26	4	8	21	1	5
April.........	22	5	1	23	14	3	25	19	3	25	17	5	21	6	1
May.........	22	2	10	23	11	8	27	0	2	25	14	2	20	2	10
June.........	21	14	6	23	16	8	27	9	9	24	10	2	19	2	2
July.........	22	2	9	23	19	6	26	15	11	23	13	11	18	14	1
August.......	22	7	6	24	14	6	27	0	5	22	1	7	19	6	9
September....	22	11	5	26	8	3	27	12	5	21	0	11	19	10	2
October......	23	1	7	28	1	7	27	13	10	21	12	11	19	15	1
November....	24	12	9	28	5	11	27	15	1	21	8	4	20	17	1
December....	24	17	1	28	14	11	27	19	3	20	3	3	20	19	2
Year.......	22	11	10	25	7	7	27	1	5	23	16	9	20	3	5

*From the Engineering and Mining Journal, N.Y.

†From the annual publication of the Metallgesellschaft, etc., of Frankfort-on-the-Main, Germany.

AVERAGE PRICES OF SPELTER, ORDINARY BRANDS, IN LONDON—(*Continued*).

Month	1909			1910			1911			1912			1913		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d	£	s.	d.
January......	21	6	3	23	4	3	23	16	9	26	9	11	25	19	1
February.....	21	8	9	23	3	1	23	3	10	26	6	5	25	4	3
March.......	21	8	8	23	0	7	22	19	2	25	19	11	24	11	4
April.........	21	10	1	22	9	11	23	13	8	25	8	10½	25	2	4
May.........	21	19	0	22	1	1¼	24	6	1	25	11	2	24	10	3
June.........	21	19	11	22	3	2	24	9	7	25	11	11	21	19	10
July.........	21	18	9	22	5	6	24	13	10½	25	13	½	20	11	2
August.......	22	0	3	22	14	0	26	11	1½	26	1	2	20	14	0
September....	22	17	1	23	2	7½	27	12	6½	26	17	0	21	3	10
October......	22	3	4	23	16	6½	27	4	10	27	5	10	20	13	9
November....	23	2	1	24	1	9	26	13	1½	26	14	3	20	14	4
December.....	23	1	3	23	17	7½	26	13	6½	26	0	4	21	6	8
Year.......	22	3	0	23	0	0	25	3	2	26	3	4	22	14	3

CANADIAN IMPORTS OF ZINC.

Compiled in Statistician's Office, Mines Branch. Calendar year ending December 31st.

	1912.		1913.		1914.	
	Lbs.	Value	Lbs.	Value	Lbs.	Value
		$		$		$
Bars, blocks, pigs, sheets and plates..........	10,009,500	617,836	4,722,600	291,368	3,160,900	189,785
Spelter..............	11,784,500	866,585	12,605,100	661,207	10,845,400	551,031
Zinc white...........	10,505,944	425,714	12,682,126	525,643	9,445,397	389,796
Manufactures of......	....	46,336	....	54,898	....	36,355
Zinc dust............	308,239	18,944	412,294	26,403	362,109	34,295
Zinc, sulphate and chloride of.............	941,780	29,104	634,634	17,424	352,715	9,390
	....	1,824,519	....	1,576,943	....	1,210,652

SPELTER PRICES, PRODUCTION AND CONSUMPTION.

Prices.—New York.

Average during 1914.............. 5.30 per lb.
Highest during past 10 years...... 7.65 in 1912.
Lowest during past 10 years...... 4.35 in 1907 and 1908.
Highest during past 30 years...... 7.65 in 1912.
Lowest during past 30 years...... 3.10 in 1895.

Production.—

United States in 1914	360,689 tons.
United States in 1904	186,702 tons.
United States in 1906	224,770 tons.

Consumption.—

United States in 1914	313,748 tons.
United States in 1906	220,781 tons.

7. *MEMORANDUM ON THE ZINC RESOURCES OF CANADA.*

BY DR. A. W. G. WILSON.

The ore of zinc commonly found in Canada is the sulphide, zinc blende. It is usually found in close association with galena, the sulphide of lead. Zinc blende has been found in a great number of localities throughout the different provinces of Canada and small trial shipments of ore have been made from time to time both to the United States and Europe. The total production of Eastern Canada has been very small and no really important discoveries of zinc ore are at present known.

In the Province of Quebec, at Notre Dame des Anges, on the north side of the St. Lawrence River, an occurrence of zinc blende almost free from lead has been receiving some attention. Shipments in excess of a thousand tons of ore, carrying slightly less than 37 per cent. of zinc, have been made within the last two years. Further development work has shown the existence of considerable ore, and I understand that a new concentrating plant has been erected at the mine. This discovery is one of considerable promise.

The occurrence of zinc and lead ores on Calumet Island has been known for many years. Exploration work has shown the existence of a small quantity of mixed sulphide ores, but the work does not appear to have proven the existence of a large tonnage. A modern concentrating mill, capable of treating about 150 tons of ore per day, was erected on the property, but was only operated for about six weeks. There have been several trial shipments, but it has not yet been brought to the commercial producing stage.

The silver-lead-zinc deposits of British Columbia have been known for many years, and at the present time are those of most importance. In the year 1906 a special Commission was appointed by the Dominion Government to report on the zinc resources of British Columbia and the conditions affecting their exploitation. The situation today is essentially the same as it was at the time the Commission made its investigations, with the exception that the known supplies of low grade zinc ores are much greater than they were in 1906, and the high grade ores are, if anything, somewhat smaller in amount, a considerable quantity having been mined and shipped since that date. The report of the Commission contains reports on all the known zinc deposits of the Province, and reports on most of the prospects. Since the report was written only about half a dozen new properties have been further developed. The following notes include extracts from the report of the Zinc Commission:—

Character of B.C. Zinc Ores.

"The zinc ore so far produced in British Columbia has been blende. No calamine has been shipped and the existence of any important supply of that class of ore has not yet been reported. The blende has been shipped partly as handsorted, lump ore, partly as mill-concentrate. The former has been of the higher grade in zinc. The grade of the mill-concentrate is reduced by the intermixture of siderite and pyrites, which occur commonly with the blende of the Slocan and cannot be satisfactorily separated by ordinary mechanical concentration."

It may be added that the ores, as shipped, contained a considerable quantity of silver. If they did not contain silver as well as zinc, it is doubtful if it would pay to mine and ship them to a foreign market.

Market for the Ores.

The zinc ore which has been heretofore produced in British Columbia has been marketed chiefly in the United States, the smelters at Pueblo, Colorado, and at several points in Kansas, Oklahoma, and Illinois having been the principal buyers. A comparatively small quantity has been exported to Europe.

Zinc Mines of British Columbia.

The report of the Zinc Commission contains detailed reports on the various zinc mines of the province, prepared by Mr. Philip Argall, Mr. Alfred C. Garde, and Dr. Alfred E. Barlow.

The Chief Commissioner, Mr. Walter Renton Ingalls, of New York, summarizes the various reports and presents certain observations of his own of the mines in West Kootenay and East Kootenay. He states that certain of the mines in West Kootenay are essentially zinc mines, but the majority are essentially silver-lead mines in which zinc blende occurs as an accessory ore.

"In this respect they differ in no wise from many other mines in the Rocky Mountains from British Columbia to Mexico, in which zinc blende occurs in association with galena, pyrite, and other argentiferous and auriferous minerals."

"The increased demand for zinc ore during the last few years, which is by all means likely to continue, has made valuable as a by-product in many cases what was formerly an objectionable impurity to be culled out so far as possible and thrown on the dump. This represents precisely the situation in connection with the majority of the mines of the Slocan. There are comparatively few which can be worked profitably as zinc mines; there are many which are worked for silver-lead ores, wherein the zinc ore will be a valuable by-product." "The yield of silver-lead ore will always be the dominating factor in the operation of these mines."

Productive Capacity.

"The method of development in the mines in the Slocan has been such that at the present time there is comparatively little ore that can be estimated as blocked out".————" The present lack of development, together with the irregularity of the ore bodies, makes it difficult to formulate any reliable estimate of the zinc producing capacity of the Slocan." Mr. Ingalls concludes—"All things considered, it is probable that 15,000 tons of zinc ore of 50 per cent. grade would be a liberal estimate for the productive capacity of the Slocan."

With respect to the mines of the Ainsworth camp, Mr. Argall, one of the Commissioners, considered that from the developments in 1906, about 54 tons daily of 50 per cent. zinc concentrate might be looked for, and that it was possible that they might be able to attain an output of 100 tons daily of 45-50 per cent. grade in the course of a few years if the extensive deposits were mined and milled on a scale commensurate with their magnitude. These estimates, which correspond to 16,000-30,000 tons per annum, are judged by Mr. Ingalls to be extremely liberal.

Since the preparation of the report of the Commission, a good deal of the zinc ore that was then available has been mined and shipped. Several new properties have also been discovered, and a few have been operated as zinc mines. The

most important of these is the Standard mine located near Silverton, B.C. According to the report of Provincial Mineralogist Robertson, this mine is to be credited with a production of about 4,000,000 lbs. of zinc in 1914, or more than half the total production of the province.

Recent extensive development work at the Sullivan mine (now owned and controlled by the Consolidated Mining and Smelting Company of Canada, with smelting works and an electrolytic lead refinery at Trail, B.C.) has shown the existence of large bodies of mixed sulphides, containing both zinc and lead. These sulphides are so intimately mixed that it is not possible to separate them by the ordinary methods. Concentrates from Sullivan ores would contain about 30 per cent. zinc and a considerable quantity of lead. They can only be treated economically by some process capable of recovering both the lead and the zinc and satisfactory recoveries cannot be attained with any of the methods now in use.

In general it may be said that only a very small tonnage of strictly zinc ores are available in British Columbia. Most of the ores containing zinc are complex silver-lead ores in which the zinc blende must be considered as a by-product, and which must usually be removed to improve the quality of the silver-lead ore. This by-product must be separated from the galena and other sulphides by special treatment, and the resulting concentrates usually retain a small percentage of the lead and considerable quantities of the iron-containing minerals (pyrite, pyrrhotite, siderite) all of which are found in the ore as mined. It is much easier to produce a concentrate comparatively low in zinc, say, about 30 per cent., than one containing 45 per cent. or over, the amount demanded by the present market. The percentage of the zinc ore lost in concentrating would also be less.

The greater portion of the ore occurring in the largest ore bodies yet developed (there are probably over a million tons available) consists of an intimate mixture of blende and galena associated with other minerals. The methods of treatment at present in vogue necessitate the sacrificing of one metal in the recovery of the other, and also make this recovery more expensive.

Present Production.

The production of zinc ores from the mines in British Columbia has been steadily increasing during the last few years. The production in 1912, according to the report of the Provincial Mineralogist, was 5,358,280 pounds. In 1913 it was 6,758,768 pounds, and in 1914 it was 7,866,000 pounds. These figures represent the zinc contained in the ores and concentrates shipped from British Columbia; a deduction of about 15 per cent. would have to be made for each year to approximate the amount of zinc that was probably recovered from these ores.

The total Canadian production of zinc in 1914 was about 8,568,000 pounds, of which about 85 per cent. would be recovered the balance representing treatment losses.

Present Consumption.

On the basis of statistics compiled in the Statistical Division of the Mines Branch, Ottawa, the total zinc imported into Canada in 1912 was about 35,015,000 pounds. The imports decreased to 31,356,000 pounds in 1913, and show a still further decline to about 23,274,000 pounds in 1914. This includes metallic zinc in all forms, zinc white, zinc sulphate, zinc chloride, and the zinc contained in brass. There is also a small amount of brass imported in manufactured forms, the weights of which are not recorded in the published returns issued by the Department of Customs, and it is therefore not possible to include the contained zinc in the figures given above.

By comparing the figures representing the annual production with those given above for the annual imports, it will be noted that the imports vary from three to five times the production. The import figures do not exactly represent the home consumption because a small amount of brass and galvanized iron are exported each year. It is not possible to estimate the amount of the zinc exported in these items because the Department of Customs does not distinguish in its records between galvanized and ungalvanized iron.

Assuming the home consumption at normal times to be 30,000,000 pounds of zinc, including zinc in all forms, or 15,000 tons per annum, the annual output of 30 per cent. zinc ore that would be required to furnish this amount of zinc, allowing

5 per cent. for losses in treatment, would have to be 60,000 tons, or about 165 tons per day. If ore or concentrates containing, on the average, 45 per cent. zinc are demanded, the annual requirements would be 40,000 tons per annum, or slightly over 100 tons per day, allowing in this case for a smelting loss of 15 per cent. of the zinc contained in the ore.

CONCLUSIONS.

In conclusion it may be stated that our known zinc ores are for the most part complex mixtures of galena, blende, and pyrite, pyrrhotite or siderite, with various gangue minerals. They also contain varying amounts of silver. Only a small portion of these ores is known to be amenable to present methods of treatment for the recovery of each of the valuable constituents of the ore, and the recovery of any one constituent, silver, lead, or zinc always involves, by present processes, the loss of a certain percentage of the other constituents.

Under present conditions the tonnage of high grade zinc ores or concentrates that could be produced from the known deposits would not be sufficient to support a smelter, provided the smelter were operated on a commercial basis. The possible production is not equal to the present Canadian requirements.

If a process were designed to recover the zinc as well as the other valuable constituents from lower grade ores than those now demanded by the present process, it is probable that British Columbia alone could produce a sufficient tonnage of this ore (containing say 30 per cent. of zinc and 20 per cent. of lead, and any silver that may be present) to supply the Canadian zinc requirements for a period at least as long as the probable life of the plant treating the ores.

SECTION XII.

Edmund B. Kirby,
Consulting Mining Engineer and Metallurgist,
910 Security Building, St. Louis, Mo.
R. 2855, 120 Broadway,
New York, June 22, 1916.

Col. David Carnegie,
Munitions Commission,
Ottawa, Canada.

Dear Sir:—

THE ELECTRO-CHEMICAL AND ELECTRO-METALLURGICAL INDUSTRIES AND ELECTROLYTIC ZINC.

The zinc situation about which information is desired is merely one detail of the general problem which presents itself to the Canadian Government with respect to the electro-chemical and electro-metallurgical industries. It so happens that conditions created by the war have made it both advisable and necessary to take up this problem without delay and furthermore they have provided an opportunity for solving it which will not appear again.

The water power resources of Eastern Canada occupy a remarkable strategic position in the industrial development of Eastern North America. Located along the United States border, they constitute to her centres of population and industry the nearest supply of cheap electric current. To Europe in general and to England in particular they present the only supply which can compete to some degree with that of Norway and Sweden.

The advantage possessed by Norway and Sweden is the combination of low installation and operating costs coupled with locations upon tide water and proximity to the markets of Europe. This advantage will be so counterbalanced by other factors for some products that Canada can compete with Norway and Sweden in European markets but for all electro products used in war, she remains the only source of supply for England which is under the British flag. The lesson taught by the war

that every Nation must henceforth be self-sustaining, and that it must establish within its own borders the means of supply for all vital needs, makes it necessary for England to establish the required plants in Canada and to maintain them against the industrial advantages of Norway.

One of the consequences of the situation described is that Eastern Canada is destined to draw to itself the principal electro-chemical and electro-metallurgical industries of Eastern North America. Norway has long foreseen that these industries will form her part in the development of Europe and aided largely by German capital and to some extent by British capital, she has been concentrating efforts upon the rapid development of electrical industries.

For American markets, the natural superiority of Canada for many products is unquestioned and if the development of the industries mentioned was a free and untrammelled process like the development of agriculture or of the more simple manufactures, it would proceed rapidly enough without notice or aid from the Government. As a matter of fact, however, its progress is so restricted and so handicapped by artificial conditions that without prompt action by the Government, Canada will have to wait a generation for something she could have immediately. The reasons for this situation will be clear from a consideration of the peculiarities of the industry.

The efficiency and adaptability of electric energy in the chemical transformation of materials has long been recognized but even after supplies of cheap current became available, the commercial applications to these purposes at first proceeded step by step and very slowly. Now the whole industrial world seems to have suddenly awakened to the importance of the new field.

Electric refining, at first applied to copper only, is now being extended to all the metals and the electric current is also employed in their extraction from the ores. The manufacture of ferro-alloys of chromium, vanadium, molybdenum, tungsten, titanium, silicon, etc. required for special steels of every description, has assumed an importance which is rapidly increasing. The production of aluminum, of calcium carbide, of the abrasives, of new refractory materials, of graphite, etc., has already created large industries. Sodium compounds and other well-known chemicals have long been manufactured by electrolysis. The

fixation of nitrogen with its many subsidiary industries, the reduction of magnesium and the production of innumerable chemical compounds known at present only to the special trades which require them, are now under commercial development.

In the development of all these industries, every forward step is covered by patents. These often lie several deep upon apparatus and processes and are frequently the occasion for litigation which delays industrial development. To monoply through patents is often added monoply through control of the raw materials or control of the market for the product so that many of the industries mentioned are already under the control of the well-known trusts whose policies in the location of plants are influenced by many considerations other than mere economy in power costs.

To the artificial constraints imposed by monoply, the tariff, etc., has recently been added the policy adopted by the Canadian Government of placing the chief burden of war taxes upon industries rather than upon natural resources. The natural industrial conditions affecting the location of new plants such as the supplies of electric current, raw materials and labour and also the facilities for transportation and marketing would even now favour Canada against the United States for many products and the number of these would be rapidly enlarged with the growth of Canadian industry. The artificial constraints mentioned on the contrary all operate against Canada. Being purely artificial, it is within the power of the Canadian Government to remove or to counterbalance them and there should be no delay in taking the necessary steps for this purpose.

Roughly speaking, the cost of electric current is about 15% of the total cost in metal refining and about 30 to 40% in the other electro-chemical and electro-metallurgical industries, If the cost of current per kilowatt-hour at a Canadian location is assumed as one-half to two-thirds of that to be obtained at an equivalent location in the United States, then the Canadian location would offer an electric current saving of something like 5 to 7% of the total cost in metal refining and 12 to 18% in the other industries. This advantage will steadily increase as electric current in the Eastern United States becomes more and more valuable for power and lighting purposes.

While economy in current will often be counter-balanced by the marketing and other advantages of operations near the

great industrial centres, it will, on the whole, steadily draw to Canada the industries, in question, but it will do so very slowly. To this situation the war has brought an opportunity for bringing about this development quickly, but in order to take advantage of the opportunity it will be necessary for the Government of Canada to act and to do so in co-operation with the British Government.

For every electro-chemical and electro-metallurgical product which can be utilized by the British Government and which can be made economically in Canada, the owners of the manufacturing patents should be presented with alternatives substantially on the following lines.

1. They shall proceed at once to construct a Canadian plant of specified size, receiving in consideration a contract from the British Government for the product at a price or profit which will be made sufficient to return the investment together with a satisfactory profit upon it.
2. In case of failure to act, the Canadian Government itself, either directly or through its appointees, will proceed to construct and operate the plant under a corresponding arrangement with the British Government. The capital required would be provided by securities based upon the enterprise itself and made sufficiently attractive to Canadian or foreign investors. A reasonable royalty fixed by suitable methods would be paid to the patent owners or in cases of patent litigation, would be set aside to await its outcome.

This exercise of the supreme power for the public welfare would be placed upon the same legal basis as those innumerable acts in which the Governments of Germany, Great Britain, France, etc., have either taken over private rights or have initiated industries which are usually left to private enterprise. If the Canadian and British Governments through this power should create certain industries in order to provide for their war needs, they would naturally continue to protect the capital invested in them. As a matter of fact, the only thing which such an exercise of supreme power would take from the patent owners would be their monoply power to exact more than a reasonable royalty or to block industrial development. The financial powers could not logically object to this deprivation, while public sentiment everywhere would heartily approve it.

ELECTROLYTIC ZINC AND THE ZINC INDUSTRY.

It is now clear that a profound re-adjustment is about to take place in this industry caused principally by two factors, the recent establishment of oil flotation processes and the commercial development now underway, of processes which replace zinc smelting and produce electrolytic zinc.

Zinc minerals are very common constituents of the ores of the world but are found most abundantly in mixed ores where blende, the sulphide of zinc, is accompanied by sulphides of the other metals. These mixtures of various minerals have been so expensive to treat that most of the zinc supply of the world hitherto has come from the more simple zinc ores, the supply of which is restricted to certain districts. These ores are milled at the mines by a standard process of water concentration which removes the rocky portion of the ore at the same time separating out any lead or iron minerals present and collects the clean zinc mineral in a condensed form as concentrates suitable for shipment to zinc smelters. This concentrate amounting to only one-fifteenth to one-twenty-fifth of the original ore mined, is itself bought and sold by the trade under the name of "zinc ore". It contains 45-60% of zinc and 25-30% sulphur. The smelters which consume 3.5 to 4.0 tons of very cheap coal or its equivalent in natural gas for each ton of concentrate treated, have to be located near supplies of very cheap fuel and good clay.

The open competition to which the business has always been subject has long compelled the utilization of the sulphur contents for the manufacture of sulphuric acid, about 1 ton of acid being produced per ton of concentrates treated. It has has also caused a steady shifting of American smelting plants during the last few years towards the eastern industrial centres where the acid made could be sold to the best advantage and where the zinc produced could most easily reach the principal consumers. Something like 80% goes to the iron and steel plants for galvanizing purposes and to the brass mills of the Atlantic seaboard. The galvanizing process also consumes much acid.

Oil flotation processes as an adjunct to a standard wet concentration secured a foothold in some parts of the world earlier than in others but about two years ago they became

sufficiently established to secure the general confidence of mine owners and engineers. Since then, oil flotation plants have been appearing at an increasing rate and their influence is changing the conditions not only for zinc but also for other important metals.

Oil flotation in conjunction with various operations of standard milling has made it possible in most cases to separate the zinc contents of mixed ores in the form of a concentrate sufficiently clean to bear the cost of shipment and to meet the conditions of distillation smelting. Such concentrates usually carrying 45 to 51% of zinc, 27 to 30% sulphur and varying amounts of gold, silver, lead, copper and iron are coming into the market in steadily increasing quantities while the supply of mixed ores available throughout the world, is such as to seriously threaten the future of those districts which produce only the simple zinc ores.

Zinc smelting by the distillation of roasted zinc concentrates in retort furnaces is a very old process. Compared with the smelting of other commercial metals, it is expensive and for various reasons has always been unsatisfactory to modern, metallurgical ideas, but it has so far held its own tenaciously. The new material is particularly unsuitable for this process but with remarkable skill and adaptability, zinc smelters have been treating the supply as it appeared, notwithstanding increased costs and metal losses.

For a generation past, inventors and metallurgists have been trying to find a substitute for zinc distillation smelting and after innumerable efforts and great expenditures, it has become clear that relief is now at hand through the electrolytic processes. In these, the zinc is dissolved out of the concentrates after these have been de-sulphurized and oxidized by roasting and the dissolved zinc is then precipitated from its solution in the form of metal of unusual purity by an electric current. Certain technical difficulties have long barred the way to success. The more noted of these being the tendency of most ores to form silicates and insoluble zinc ferrites while being roasted, the expense of securing a strictly iron-free electrolyte, difficulties in securing a product as pure as the best grades of zinc produced by smelters from the purest ores, and also various troubles with the anodes employed.

Just prior to the outbreak of the war, only one process was attracting attention, this being based upon patents by Dr. P. C. C. Isherwood, of England. The Refractory Zinc Ore Treatment Co., of New York, an Anglo-American Company owning the patents, had announced some time before the completion of its experimental and development work and its intention of constructing an intial unit plant as soon as the zinc market recovered from the depression then existing.

This recovery came suddenly in January, 1915, and the unprecedented prices which have prevailed ever since, particularly for the pure grade of zinc needed in cartridge making, soon turned the attention of the industry to the old problem of producing electrolytic zinc either by the treatment of ores or by the electrolytic refining of common zinc. During the past 12 months, therefore, a number of concerns have undertaken to create electrolytic processes.

ELECTROLYTIC ZINC PLANTS

UNITED STATES

Company	Location	Capacity	Remarks
Amer. Smelting & Ref. Co.....	Omaha, Neb....	1 ton metal daily.	Experimental
Amer. Smelting & Ref. Co......	Garfield, Utah..	10 tons metal daily	Planned.
Anaconda Copper Mfg. Co......	Anaconda, Mont.	25 " " "	Under construction, 10 tons operated in 1915.
Anaconda Copper Mfg. Co.....	Great Falls, Mont	100 " " "	Under Construction.
Bully Hill Copper Mfg. Co......	Bully Hill, Cal..	10 " " "	Under Construction.
Electrolytic Zinc Co...........	Baltimore. Md...	10 " " "	Constructing, 7 tons now in operation
Mammoth Copper Mfg. Co....	Kennett, Cal....	....	Experimental
Reed Zinc Co.................	Palo Alto, Cal...	....	Operating in 1914–15.
River Smelting & Ref. Co.......	Keokuk, Iowa...	....	Experimental.
R. M. Atwater...............	Basin, Mont....	1 " " "	Initial unit Isherwood process under construction.

OTHER COUNTRIES

Company	Location	Capacity	Remarks
Con. Mining & Smelting Co.....	Trail, B.C......	50 tons metal.....	Now operating.
Weedon Mfg., Co............	Welland, Ont....	5 tons metal.....	Watts process, 1 ton operating experimentally.
P. P. C. Isherwood..........	England........	1 ton metal......	Initial unit Isherwood process, under construction.
Brunner-Mond & Co..........	England, Winnington.....	2 tons metal.....	Höepfner process, long operating, producing chlorine, etc., by-products.
Hoepfner Process.............	France,.........	....	Höepfner process, long operating, producing chlorine, etc., by-products.
2 small plants................	Japan..........	....	Operating past 3 years.

The total output of electrolytic zinc in the United States to April 4, 1916, was only 252 tons but it was then estimated by the statisticians of the U.S. Geological Survey that by the close of 1916, electrolytic zinc would be produced in the United States at the rate of over 60,000 tons yearly.

How many of the above electrolytic processes can live after the price of zinc falls to its normal level is an open question. The only process whose details I happen to know is the Isherwood which, at normal prices, can unquestionably treat the new mixed metal concentrates at a lower cost and with higher recovery than the standard process of zinc smelting. It can also produce a metal more nearly chemically pure than any smelting product.

The world's production of zinc under normal conditions is best shown by the statistics for 1913 (production is credited to those countries in which the smelting was done).

WORLD'S PRODUCTION FOR 1913.

	Tons of 2000 lbs.	
United States	346,676	
Germany	311,914	Includes zinc from about 525,000 tons of Australian concentrates smelted.
Belgium	217,941	
Great Britain	65,201	
Other Countries	161,627	
	1,103,359	

United States produced in 1915	489,519
United States capacity by end of 1915 (estimated)	900,000

The zinc of the world is produced only where very cheap coal and other smelting conditions attract the supplies of concentrates.

Germany, Austria and Belgium together produce about 150,000 tons of metal in excess of their consumption, this tonnage constituting the supply of England, France and other countries.

Under normal conditions, the United States produces about as much zinc as it consumes.

That portion of the Australian concentrates which has hitherto gone to Germany for treatment is understood to have been from 250,000 to 300,000 tons.

PRESENT CONDITION OF THE INDUSTRY.

As a result of war conditions, the United States zinc industry was suddenly called upon not only for an unusual amount of pure zinc, but for common zinc enough to furnish England, France, etc., with the 150,000 tons yearly formerly supplied by Belgium, Germany and Austria and also the additional amount required for war uses. Under this stimulus it has grown to a dangerous degree and is still expanding. By the close of 1916, the productive capacity as estimated by the Government, will be nearly three times the normal consumption of the United States and nearly nine-tenths of the normal consumption of the entire world. A crash in the industry is therefore due to arrive at any time.

Since the British Government has determined that hereafter no portion of the Australian concentrates shall return to the German industry an equivalent smelting capacity must be immediately provided elsewhere. In addition, provision must be made for the treatment of another large English-owned supply of similar concentrates already exposed in the Bawdwin mine of Burma and due to come upon the market soon after the restoration of peace. For the reasons previously given, an indefinite further increase of such material is to be expected from many parts of the world, all of which must seek either coal or power and also markets for its zinc, sulphur and smelting residue. Up to the present moment, no satisfactory solution for the problem presented has been found and there is apparently much confusion of opinion as to what it is best to do.

The zinc smelter at Port Pirie, N.S.W., which has been treating about 25,000 tons of concentrates yearly is handicapped by expensive coal and labour and also by its distance from market, so that its further expansion seems improbable.

It is understood that Japan is trying to increase her zinc industry so as to take some Australian concentrates but it is not known whether such plans have taken form. Japan has no cheap power.

A new electrolytic plant in northern Italy to use power from the Alps, is said to be either experimenting or operating in a small way. Alpine power, with the dense population surrounding it, is in demand for so many uses that it can never approach that of Norway in cheapness.

An increase of zinc smelting capacity in England is being seriously considered and may be already under way but it is difficult to see how the problem can be solved in this way. Neither coal nor power are cheap in England nor can the highly skilled labour required for zinc smelting be secured except by slow degrees. Moreover, the world is already over-supplied with facilities for smelting zinc ores by a process that is about to be largely replaced by a new one. Yet something must be done and done quickly, for it takes time and much capital to construct the new plants required for the large tonnage described.

Tasmania has cheap water power and it is reported that an electrolytic plant there for the treatment of 200,000 tons of concentrates yearly is now under consideration. Apparently little or none of the sulphur contents could be utilized at that location.

That portion of the excessive American smelting capacity which is so soon to be shut down could, of course, be utilized for the treatment of these supplies, and during the past year about 125,000 tons of Australian concentrates have been sold to works in the United States. Aside from the fact that this solution of the problem (except as a temporary makeshift) would not accord with the policy imposed upon the British Government, it would not be sound industrially because these concentrates are of the new type and can be treated efficiently only by an electrolytic process. New plants for these processes will, of course, soon be built in the Eastern United States to deal with the increasing supply of such ores available at Atlantic seaports.

AN ELECTROLYTIC PLANT IN CANADA.

A Canadian electrolytic plant located upon tide-water, would of course be barred by the tariff from the United States markets but it would, without aid, meet any selling competition of American plants in the general English market. Its reduced power cost would counterbalance the advantages of an American plant in the utilization of sulphur. Sulphuric acid is worth more near Niagara Falls or near the power systems of the southern Alleghanies. Nevertheless, the pulp mills of Canada could, with proper equipment, utilize the sulphur gases in the sulphite fibre plants while a supply of Canadian zinc would create a galvanizing industry in Canada which would also be a consumer of acid. Against the competition of present European smelting plants, Canada could stand without assistance. She would, however, require the aid of the British Government against the future electrolytic plants of Norway and Sweden.

In competition for the supply of concentrates, a Canadian plant could meet open competition for the Atlantic Ocean supplies of the future, while for those controlled by Great Britian it would have an unquestioned though artificial advantage.

The plant should be built upon the basis of a contract for its supply of concentrates from the Broken Hill District, Australia, and a contract for the sale of its zinc to the British Government, these contracts being enough to cover the investment together with a satisfactory profit upon it. The process adopted should be carefully selected by an investigation of those now in the

field and its owners should be offered the alternatives previously described of proceeding with the enterprise themselves or of submitting to construction and operation by the Canadian Government or its appointees.

While the plant or its preliminary units could be built in time to serve the present war needs of the British Government and its Allies, the investment would really stand upon a permanent basis; that of its ability to compete with the smelting plants of the world upon mixed ores when zinc returns to its normal level of 5 to 5.5 cents per lb. Except for protection, against Norwegian competition, the direct co-operation of the British Government would be needed only during the first few years.

The premium hitherto paid for pure zinc above the market price for common spelter, will probably disappear for a time after the war ends but purity brings so many advantages to the consumers of zinc products that electrolytic zinc is certain to gradually displace the common for most purposes.

APPROXIMATE DATA FOR AN ELECTROLYTIC PLANT.

Broken Hill concentrates which are typical of the new supply except that they lack the usual gold contents, have about the following composition:—

Average Analysis		Approximate products per ton of 2000 lbs. of raw concts. bought.
Silver (per ton of 2000 lbs.)......	10·7 oz.	884 lbs. of electrolytic zinc.
Zinc............	47·0%	700 lbs. of residues for lead smelt.
Gold............	....	525 lbs. of sulphur burned.
Lead...........	7·0%	1900 lbs. of acid produced.
Copper..........	0·5%	
Sulphur.........	30·0%	
Other components	15·5%	
	100.	

An electrolytic plant would be constructed in successive units but when completed to the most effective size it should produce about 100 tons of zinc per day, or, say, 33,000 tons yearly. The following data which are, of course, only approximate at this stage, will indicate roughly the principal results to be expected.

Supplies	Per day, tons	Per year of 330 days, tons.
Raw concentrates imported	226	57,000
Products		
Zinc, electrolytic.............	100	33,000
Sulphur, burned.............	59	19,500
Sulphuric acid made (66°B—78% H_2SO_4)............	214	70,000
Residues for smelting........	79	26,000

The raw concentrates would be roasted at the most convenient pulp mill or acid works and then sent to the electrolytic plant. At normal rates for shipping, it would be practicable for concentrates coming from the Orient, Australasia, South America and Mexico to be shipped first to England where sulphuric acid is most valuable and to have its sulphur utilized there. The roasted concentrates would then proceed to Canada for the extraction of zinc and the other metals.

The residues from the zinc extraction would contain the lead, copper, gold, silver and iron present in the original concentrates and would constitute a basic fluxing material desirable in standard lead smelting. It would either be sold to established lead smelters or be smelted directly in the works.

The roasting plant would use about 0.25 tons of coal per ton of concentrates, this being dependent upon the coal and type of furnaces used, say, 19,000 tons yearly.

The electrolytic plant would use for various purposes something like 1.6 tons of cheap coal per ton of zinc, or, say, 53,000 tons yearly. The electrolytic plant would also use about 14,000 kilowatts of electric power.

The cost of the roasting and acid plants can be estimated only by the pulp mill or acid works concerned as it will depend upon the equipment already existing. The cost of the electrolytic plant would be roughly about $1,800,000 at normal prices for the copper and machinery used. The present war prices would increase this figure and they make a special estimate necessary.

THE ZINC MARKET AND ELECTROLYTIC ZINC.

The zinc supply of the American market comprises a large number of brands, each having its own quality and trade

reputation. They are grouped by the trade into four classes, "High-grade," "Intermediate," "Brass Special," and "Prime Western." The great bulk of the tonnage produced is "Prime Western" or common "spelter" and the market reports generally quote this only.

The "High-grade" class which is but a small fraction of the total tonnage comprises those brands which are over 99.9% zinc. The bulk of this class is represented by two brands, the "Horsehead" and the "Bertha," both made by the New Jersey Zinc Company from the pure ores of their noted mine at Franklin Furnace, New Jersey. These brands have long been specified by the military authorities of this country and Europe for the manufacture of cartridges, both for artillery and small arms and for some 14 years the German Government has been accumulating them for this purpose. They have always commanded a price of about 2.5 cents per lb. above the market quotations for common or "prime Western" spelter which usually ranges between 5 and 5.5 cents per lb. in New York.

The war demand promptly tied up the supply of these brands far ahead at prices which remained in the neighborhood of 40 cents per lb. until recently when it was lowered to about 30 cents. Other less known brands of "High-grade" have been sold all along at 3 to 5 cents less than the price of "Horsehead" and "Bertha." Meanwhile common spelter has fluctuated wildly, at one time reaching the neighborhood of 30 cents then remaining for sometime at about 18 cents and now being quoted in the neighbourhood of 12 cents.

Under war conditions, therefore, the circumstances which fix the market price of common or "Prime Western" zinc have suddenly become different from those affecting pure zinc as though the two were distinct metals. The war not only cut off the Belgian, German and Austrian supplies of common spelter, but also created an unprecedented demand for the chemically pure zinc necessary for the manufacture of cartridge brass.

The present condition of the spelter industry is that of an over supply of ore and concentrates and a shortage of smelting capacity, particularly of roasting capacity. To meet the shutting down of the European plants all the inactive capacity of the American smelters is being brought into service, together with all revivals and additions possible. Several large new plants are

under construction and the full productive capacity now under preparation by American smelters is to be reached during the latter part of 1916.

On the other hand for the more serious difficulty, the shortage of really pure spelter, there does not seem to be any adequate relief in sight. The owners of the limited supply of pure ores cannot make any further increase in their production. Every technical expedient known to smelters to secure special purity for portions of their product seems to be already in use, but most of this emergency product falls into the "Intermediate" class, which, during normal times, would not be accepted for cartridge brass.

The list of electrolytic plants, previously given, which have sprung up under the stimulus of high price for pure zinc, will, even if all are successful, fall short of relieving the need and displacing the impure zinc now being used for cartridges. Small arms and artillery cartridges ought not to be made with spelter of any less purity than 99.95% zinc, but since there has not been enough of this quality to go around, manufacturers are now using, with or without the knowledge of the Governments, spelter as low in grade as 99.75% zinc. The brass and cartridge manufacturers are not seriously concerned about the quality of their product so long as the purchaser has no alternative. The purchasing governments, however, cannot avoid the consequences of impurity. They have been obliged to relax their original requirements to meet the realities of the spelter supply, but even the military experts do not seem to know just how far this can go without serious consequences in the field. Aside from the question of season cracking and of re-use, jamming difficulties at critical moments may have almost any consequence.

The simple facts are that the military and manufacturing experts of all countries, including those of Germany, have always been in accord as to the necessity of using pure zinc for cartridge brass, also that the supply of zinc having the required purity has been mainly restricted to the "Horsehead" and "Bertha" brands.

Ever since the war demand overran this restricted supply, the Allied governments, who had not like Germany, laid in a store of these brands, have had to endure the substitution of impure zinc by the cartridge makers, to the extent of the shortage. As soon as a supply of electrolytic zinc of 99.95% grades becomes

available, there will be no longer any excuse for the use of inferior grades and it should be made to replace these as fast as it can be obtained. The purchasing governments, themselves, will have to watch and encourage its production and must force the brass mills to substitute it, for neither the brass men nor the cartridge makers will do so of their own accord.

Probably no metal is subjected to more severe treatment than cartridge brass in the drawing presses, and it requires the best grade of brass to stand these strains. Very slight amounts of impurities make the metal more sensitive to the irregularities in its mechanical and heat treatment. Moreover, one of the strange peculiarities of brass is that defects in its composition and micro-structure start injurious changes which often progress rapidly during storage and after the brass has left the factory. Cartridges made from impure material do not keep well but are apt to crack in storage, especially in hot climates.

Very truly yours,

(Sgd.) E. B. KIRBY.

SECTION XIII.

MEMORANDUM ON THE SECURING OF EMERGENCY SUPPLIES OF COPPER AND ZINC FROM CANADIAN ORES.

The following recommendations with respect to the securing of an emergency supply of copper and zinc for munitions manufacture are made on the understanding that an adequate supply of these metals cannot be secured in the United States. While a limited supply of these two metals could be obtained in a comparatively short time after orders were placed, it must be clearly understood that a large supply of either copper or zinc cannot be procured by the methods indicated, and it is extremely improbable that the production could sustain itself as a commercial enterprise.

ALFRED W. G. WILSON.
Chief Engineer, Metalliferous Division,
Mines Branch, Department of Mines.

1. *AN EMERGENCY COPPER SUPPLY.*

The best location for a copper refinery in Canada from a commercial point of view would be at some point in the province of British Columbia accessible to tide water. Owing to certain circumstances such a refinery could not be established and put in operation in less than two years unless it became necessary to take the drastic step of compelling the present operating companies to break existing contracts and to refine their products in Canada.

To obtain an emergency supply of copper the following courses are open:—

1. Notify present producing companies that they must deliver at a stated price to the Canadian Government, at a designated point, all copper produced by them, or the equivalent thereof. Their course would be to have their copper refined in the United States under bond and returned to Canada—or they would threaten to close the mines and smelters. In this event the properties could be operated by the Government and the product could be refined in the United States in bond and returned to Canada.

2. Start a refinery, and secure for this refinery as much of the available Canadian copper production as possible with or without coercion. The refinery could be Government owned, privately owned, or privately owned but subsidized directly or indirectly by the Government.

   (*a*) A refinery owned by the Government does not appear practicable at the present juncture, though the erection and equipment of such a plant, coupled with legislation requiring all companies to deliver to the Government refinery all their production is worthy of consideration. The principal stock argument against such an enterprise is that the Government could not operate such a plant economically

   (*b*) A privately owned refinery is not practicable at present. The reasons why such is not now available are:—

      I. Small total production of copper in Canada has rendered the operation of such a plant impossible as a commercial enterprise.

      II. Foreign control of the markets of the world make it difficult to enter into competition with other refiners.

      III. About 90% of Canada's copper production is in the hands of foreign owners who are interested in established refineries in other countries.

      IV. I believe a concerted effort has been made among certain groups of operators to discourage and prevent the establishment of metal refineries in Canada, and that it would have been difficult to finance such enterprises in the past, and that the products could not have been easily marketed.

   (*c*) A privately owned refinery subsidized by the Government, directly or indirectly, is quite practicable. In construction, organization, operation and management it could have all the supposed advantages of private control. The Government could assist in the financing of the operation, in the providing of a market for its products, and in protecting it

from financial loss and unfair competition. Personally I consider that the Government should also share in the profits of such a concern, if any, as a part owner rather than act only as beneficent protector. This enterprise could be started in one of two ways:—

I. A corporation could be organized to start a refinery and the complete new plant could be designed and then erected on a suitable site. Such an organization could not be organized and the plant designed and erected in less than a year, and probably at least eighteen months would be required, and the capital expenditure would be large (between $500,000 and $750,000 for a daily production of 50 tons of copper.)

II. Advantage could be taken of existing organizations, and plants, and such additional equipment as is required could be secured. This is the only method by which a supply of copper can be obtained in the shortest possible time. If this method is adopted it is probable that arrangements can be made for the first deliveries of small amounts within about two month's time. For this reason, and only because an immediate supply of refined copper appears to be necessary, the writer recommends consideration andthe acceptance in modified form of the proposal made by the Canadian Consolidated Mining and Smelting Company through its President.

PRODUCTION OF REFINED COPPER AT TRAIL.

With regard to the production of refined copper by the Canadian Consolidated Mining Company in its works at Trail, B.C., the following comments are offered:—

1. This is the only strictly Canadian corporation in business in Canada mining and smelting copper ores.

2. The technical staff at Trail is the best available staff of its kind in Canada, is well organized, and is quite capable of starting the enterprise in the shortest possible time.

3. The additional plant needed to start a copper refinery is less than at any other works in Canada. Electric power is now available on the ground. The new plant needed will be additional transformers, motors and generators to produce direct current, a tank house, tanks and their equipment. The works are already provided with all the auxiliary equipment needed, such as blast furnaces, precious metal refinery. blue-vitriol plant, etc.

4. The company owns and controls a supply of copper ores, which in previous years has yielded about 6,000,000 lbs. of copper per annum. It could from its own ores produce about 17,000 lbs. or about 8.5 tons of copper per day, or possibly 10 tons per day in an emergency for a considerable period of time. In addition there are the mines at Phoenix now producing about a million lbs. of copper per month, which is smelted at the plant of the Granby Consolidated Mining and Smelting Company at Grand Forks, B.C., and also the mines at Deadwood with the smelter at Greenwood, owned by the British Columbia Copper Company, which are not now in operation. If proper action is taken the other two companies can be persuaded or compelled to send blister copper to Trail, unless their contracts are ironclad, and the output could be very materially increased. The maximum possible would be about 25 tons per day.

5. The capital investment needed to install additional plant at Trail to produce refined copper in about two month's time will be in the neighbourhood of $150,000. It is probable that a plant on the coast would cost about 30% more than a similar plant in the eastern United States, and that at Trail nearly 50% more, provided a complete plant were erected. Owing to the fact that Trail is already provided with an excellent technical staff, efficient labour, and a portion of the necessary plant, a small refinery can be started here cheaper than elsewhere in Canada, and in a much shorter time. Additional capital to finance the operations of the plant, owing to the capital

locked up while the copper is passing through the plant may also be required.

6. The cost of refining copper in the Eastern United States varies somewhat with the character of the material supplied to the refinery. In a general statement of costs it may be placed at 0.6 cents per lb. In a few cases it is less than this, and in some cases it amounts to as much a 1.0 cent per lb. The cost of refining copper from British Columbia ores at a coast refinery producing at least 50 tons per day should not exceed 0.8 cent per lb. At Trail, with a production of say 15 tons per day the cost should not exceed 1.5 cents per lb. produced. Additional data are needed from Trail on which to base a more accurate estimate of the probable cost per lb. of copper produced.

7. The cost of marketing refined copper varies from about 0.2 cent per lb. to about 1.0 cent. Refined copper produced at Trail under contract with the Government would be free from a marketing charge. In making an agreement with the Company this fact should be kept in mind and used to offset the additional cost of refining at Trail.

8. Freights on the refined product, which would probably be ingots for brass making, would be a matter of adjustment with the transportation companies.

9. In making an agreement with the Consolidated Mining and Smelting Company the following items should be investigated and adjustments made:—

    (*a*) The company should submit a sworn itemized statement of the costs of refining their matte for each year during the last five years, showing the amounts of copper, nickel, and precious metals recovered, and the charge for refining the copper, gold, silver, and such other metals as were paid for, and the marketing charges. The itemized statement should show refining charges, freights, commissions, penalties, and deductions. From this statement a fair estimate can be made as to the cost of refining their copper productions in an established refinery.

    (*b*) The guarantee (if any) for the increased cost of refining, because of the location at Trail, should take account of the market price of copper, and should

be on a sliding scale. When copper is high, copper can be refined very profitably at Trail as well as in the east, the only difference is that it will cost a little more at Trail, and therefore, the profits to the company will be a little less. Moreover, on account of the peculiar nature of the Rossland ores, it is probable that in refining at their own plant at Trail the company will recover more gold and silver than would be acknowledged and paid for by a foreign refinery. This additional recovery will materially offset the increased cost of refining the copper at Trail.

(*c*) The agreement should include a clause requiring a detailed accounting system for the refinery, subject to examination by a Government Auditor, and designated technical officers of the Government should have the right of entry to the works.

(*d*) The cost of refining at Trail would be determined after due credits had been given for the recovery of the precious metals and other by-products.

(*e*) The bonus (if any) per lb. to be paid during the period when all copper produced is to be delivered to the Government would be the difference between the cost of refining at Trail (as above determined) and the sum of the cost of refining at an Eastern refinery and the average marketing and freight charges previously paid.

(*f*) The bonus (if any) per lb. to be paid during the continuation of the bounty (if such be established) and after direct deliveries to the Government have ceased would be the difference between the cost of refining at Trail (as above determined) and the sum of the cost of refining at an eastern refinery and the excess marketing and freight charges over and above those formerly paid.

2. *AN EMERGENCY ZINC SUPPLY.*

A supply of zinc can be obtained from British Columbia in a comparatively short time by entering into an agreement with the Canadian Consolidated Mining and Smelting Company to produce the same.

The following facts are submitted herewith for your consideration:—

1. There are now available from British Columbia zinc mines ores which were formerly sold in the United States, but which, for the most part, are at present unable to find a market. There is also available a large supply of ores of too low a grade to be marketed under normal conditions. These ores could easily be shipped to the works at Trail. The Consolidated Company itself owns a large body of silver-lead-zinc ore which could contribute concentrates containing about 30% zinc.
2. Additional ores could easily be purchased in the United States, if necessary.
3. The Consolidated Company has adopted and improved, but not perfected, the Letrange process for producing electrolytic zinc. They are producing about 500 pounds of zinc per day, and will shortly produce 1000 lbs as soon as certain necessary aluminum sheets are secured. They have not perfected the process, and the cost per pound of zinc produced is two or three times that obtained by standard processes (2.5 cents per lb.). There are also certain technical difficulties which have arisen from the production of certain residues and solutions. These will have to be overcome to render the process a commercial success under normal conditions. The main fact is that the process is capable of producing zinc from British Columbia ores. If the output of the plant were materially increased to produce a larger tonnage of refined zinc, these residues and products could be stored for future treatment, or even discarded.
4. To enlarge the plant the following additional equipment would be needed:—Wedge roasters, a tank house, tanks, aluminum starting sheets, equipment for the tank house, transformers, motors and generators to produce direct circuit and additional buildings to house the plant.
5. There is a surplus of about 15,000 h.p. (which can be very quickly raised to 20,000 h.p., if necessary) available for use in the electrolytic refining of both copper and zinc. If the whole of this power could be utilized, the power costs could be reduced to almost one-half their present amount.

6. Probably about 25 tons of zinc per day could be secured, costing for refining only perhaps about 5 cents per lb. The total cost for production would possibly be about 9 cents per lb.
7. The process is new and untried on a large scale and therefore results cannot be predicted. There are ores available for a 50 ton daily production, if success attends the first enlargement.
8. An alternative suggestion, which would not be capable of producing refined zinc in less than a year, would be to establish a standard zinc smelting plant on the Pacific Coast, import suitable Australian ores, and utilize such ores from British Columbia as can be treated economically.

3. *COMMERCIAL DEVELOPMENT AFTER THE WAR.*

COPPER.

I do not think that a copper refinery at Trail can be operated on a commercial basis for any length of time. During the life of the Rossland mines it may be profitable to the Consolidated Mining and Smelting Company to operate such a refinery because the additional saving of gold will more than offset the additional cost of refining the copper. It is probable that the company would have started a refinery for this purpose without assistance.

The copper mines tributary to the Pacific Coast are rapidly increasing their production, and give promise of much greater output some years hence. The copper mines east of the Cascades are on the decline, and unless new deposits are opened up, the supply of ore available for treatment at Trail and other interior points will be very small.

A coast refinery will possess the advantages of cheap power, lower costs for supplies, lower wage scale, cheaper transportation, wider territory from which to draw ore, and cheaper access to both the home and the world's markets.

ZINC.

If the present processes are employed on a large scale for the production of zinc at present costs it is very probable that methods will be discovered to reduce the costs of operation as the market price of zinc falls. In other words, the study of the operation of the process on a large scale will bring out its defects which possibly can be corrected.

The ordinary processes of smelting with coal or gas are not applicable to at least 75% of British Columbia ores. The electric process is applicable to all of the ores, both high grade and low grade.

The plant at Trail is located close to the territory in which nearly all of British Columbia's zinc ores are produced. The principal item of cost of operation of the plant will be the power cost. If the plant is made large enough to utilize nearly all of the power developed and now available, the cost of this power per unit of production can be very much reduced below present costs.

I therefore think that an electrolytic plant at Trail will probably be able to maintain itself as a commercial enterprise at the close of the present emergency period. It is possible that the over-production in the United States, which is bound to come may break the market for a time, but this will gradually correct itself.

A standard zinc smelter at or near Medicine Hat does not appear advisable because:—

1. It could not be started within a year.
2. Most of the supplies needed would be drawn from the United States, and at present United States smelters are drawing on these supplies very heavily.
3. Such a plant could not profitably treat more than a quarter of the available ores from British Columbia.
4. The gas supply for a sufficiently long period is not assured.
5. It is probable that the draft on the gas fields caused by such a plant would deplete the gas supply before the plant is worn out. It would then have to be rebuilt for coal firing.
6. It is an unjustifiable waste to use such an ideal domestic fuel for commercial purposes at a low charge, and for a very limited period of time.
7. The deleterious fumes and gases from such a plant would cause trouble with neighbouring agricultural interests, or would entail extra expense to prevent their escape.

A standard zinc smelter located on the Pacific Coast of British Columbia, using California oil fuel or Vancouver Island coal, and supplied with suitable ore from Australia might possibly be able to produce zinc on a commercial basis. Such a plant could treat such British Columbia ores as are amenable to this method of treatment.

SECTION XIV.

ACTION TAKEN BY THE GOVERNMENT AND LETTERS RELATING THERETO.

1. May 22, 1915, Consolidated Mining and Smelting Company to Minister of Militia and Defence. Offer to install copper refinery of 10-15 tons capacity on an advance of $50,000 and promise of bounty to cover extra cost of refining at Trail. Copper to be at disposal of Shell Committee at current market price. Letter appended.
2. May 26, 1915, Col. D. Carnegie to Minister of Militia and Defence. In view of probable expense of $200,000 for starting copper refinery consider an advance of $50,000 reasonable. Extra cost of refining at Trail should not exceed 2c per lb. and bounty in one year not over $150,000. Refinery on the coast would cost $1,500,000 including smelter, and in view of American contracts better to start at Trail. Letter appended.
3. May 27, 1915, Col. D. Carnegie to Minister of Militia and Defence enclosing table showing weights of copper and other materials required for War Office contracts. Letter and table appended.
4. June 2, 1915. Col. D. Carnegie to Minister of Militia and Defence, enclosing statement of copper and brass imported into Canada during 1913. War Office contracts require in addition 23,000 tons of copper. The Trail output of 15 tons daily, 5,500 tons yearly, would help. Users of copper agree that refining in Canada should be undertaken. Letter and table appended.
5. June 15, 1915, James J. Warren to Minister of Militia and Defence. Trail plant in position to make zinc commercially. Usual custom to put in small unit and test for six months, but willing to put in large plant at once, which may be useless after the war. Asks loan to meet this as have made heavy expenses to increase lead output. Have ample ore in own and neighbouring mines. Letter appended.
6. June 15, 1915. James J. Warren to Col. D. Carnegie, referring to No. 5. Cost of making zinc will be above normal, but

profitable at present prices. Would also install a Belgian plant if desired. Letter appended.

7. June 8, 1915, Alfred Stansfield to Col. D. Carnegie suggesting a bounty of 1c to 2c per lb. for Canadian zinc.
8. June 10, 1915, Alfred Stansfield to Col. D. Carnegie. Smelting 40% zinc ores in States may cost 1.5c to 2.0c per lb. of zinc and in Canada 2.5c to 3.0c so 1c per lb. would place on equality. Treating rich ore in States might cost 1c per lb. of zinc and a poor ore in Canada 3c, per lb. of zinc, thus needing a bounty of 2c per lb.
9. June 24, 1915, Memorandum by Col. D. Carnegie. Proposals to produce metallic zinc and copper commercially in Canada. Memorandum appended.
10. July 3, 1915. A. W. G. Wilson to Col. D. Carnegie. Refers to Cabinet Committee Meeting on copper and zinc situation. Hon. T. White asks whether any grave fears are held in regard to the supply of copper or zinc, and in what way the Canadian zinc producers can be aided by the Government. Letter appended.
11. July 7, 1915. The Hon. T. White, Minister of Finance, to Col. D. Carnegie. Refers to request that electrolytic zinc production be started at once and to suggestion of advance of capital for this purpose. Asks (1) if zinc cannot be obtained from United States; (2) if proposed process at Trail really satisfactory; (3) if a sliding scale bounty would meet the case. Letter appended.
12. July 12, 1915. (1) Gen. A. Bertram to Hon. T. White, Acting Premier, enclosing the following letter and papers; (2) Col. D. Carnegie to Hon. T. White, Acting Premier, replying to No. 11.
    1. High grade spelter unobtainable for cartridge case brass.
    2. Process at Trail making 1,000 lbs. per day, which can be greatly increased.
    3. Sliding scale bounty probably acceptable.
    4. While the copper supply is less urgent some encouragement should be given to copper refining in Canada.

    Letters and papers appended.
13. June 28, 1915, Alfred Stansfield to Col. D. Carnegie. Givi n information with regard to operation of the French proc

and suggesting that the Standard Company be encouraged to install a plant for making zinc by this system. Letter appended.

14. Contract with Consolidated Company to supply spelter. Bounty offered for Canadian spelter. Papers appended.

I.

The Consolidated Mining and Smelting Co.,
Ottawa, May 22nd, 1915

To General The Hon. Sam Hughes,
Minister of Militia and Defence,
Ottawa, Ontario.

Sir:—

Referring to our interview of today, we are willing to proceed at once with the installation of a copper refinery in connection with our smelter at Trail, B.C. (to have a daily capacity of from ten to fifteen tons of refined copper) upon your advancing or agreeing to advance fifty thousand dollars as a contribution towards the cost of the installation—and upon your agreeing that Parliament will be asked at the next Session, to pay a bounty in respect of each pound of refined copper produced, sufficient to put us on an equality as to cost of refining only, with American refining plants of large capacity.

In consideration of this arrangement, we will hold our entire production of refined copper at the disposal of the Militia Department and the Shell Committee for use in the manufacture of munitions of war, at current market prices.

Of course, it is understood that the Militia Department or Shell Committee will notify us of their intention to purchase as the copper is refined.

We have the honour to be, Sir,
Your obedient servants,

THE CONSOLIDATED MINING AND SMELTING CO.

(Sdg.) W. D. MATHEWS.
J. J. WARREN.

Colonel D. Carnegie, Chairman, Zinc and Copper Commission,
Ottawa, 22nd May, 1915.

To General The Hon. Sam Hughes,
Minister of Militia and Defence,
Ottawa, Ontario.
Sir:—

Referring to the conference we had today at the Rideau Club, I have the honour to transmit herewith, a letter signed by Mr. Matthews, President of the Consolidated Mining and Smelting Company of Trail, B.C. and Mr. Warren one of the Directors of the same company.

The letter as you will observe contains a proposal to install immediately a small plant for the refining of copper in their works at Trail, B.C.

The accumulated facts that I hope to submit in due course, as a result of the investigations of the Commission, will be found to warrant this conclusion. Meanwhile I am enclosing a preliminary report on the subject.

I also attach to this letter our preliminary conclusions on the subject.

I have the honour to be, Sir,
Your obedient servant,

D. CARNEGIE.

II.

Colonel D. Carnegie, Chairman, Zinc and Copper Commission,
Ottawa, 26th May, 1915.

General The Hon. Sam Hughes,
Minister of Militia and Defence,
Ottawa, Ontario,
Dear General:—

With reference to your request of last night for some data to guide you regarding the amount of bounty which should be paid to Trail, I have had the opportunity of calling Drs. Wilson and Stansfield together this morning, and we together have considered the following, which I hope you will regard as subject to modification in detail.

1. That as the Consolidated Mining and Smelting Company have plant at their works which only requires the addition of say $100,000 expenditure, to make it suitable for the production of 10 to 15 tons of copper per day, and the probable additional cost to that for operating, in the way of capital would be approximately $200,000, we think that an advance of $50,000 towards the cost of the plant reasonable.

2. The actual difference in the cost of refining in America and Canada can only be estimated very approximately, as no data are available at the present moment to guide us. We, however, estimate that the difference should not exceed two cents per lb., and in any one year the bounty granted to the company should not amount to more than $150,000.

With reference to the comparative cost for the establishment of a refinery on the coast, we would point out that this cost would be in the region of $1,500,000, including the necessary smelting plant as well as refinery.

In view of the existing contracts between the Mining Companies of Canada and the Refineries in the United States, it is in our opinion advisable to commence operations at Trail, where refined copper is likely to be obtained in about six months.

We hardly need remind you that Germany has built herself up as an industrial nation on the bounty system.

I have the honour to be, Sir,

Your obedient servant,

D. CARNEGIE.

P.S.—With reference to the zinc situation, we hope to report fully in due course.

III.

Colonel D. Carnegie, Chairman, Copper and Zinc Commission,

Ottawa, May 27th, 1915.

General The Hon. Sam Hughes,
Minister of Militia and Defence,
Ottawa, Ontario.

Dear General:—

In accordance with my promise, I enclose herewith a brief summary of the total rough and finished weights of the materials required for the manufacture of ammunition now on hand for

War Office contracts. The rough weights given are approximate, the finished weights are accurate.

I enclose in addition to the foregoing totals, *sheets showing the material required for each nature of shell contract.

I have the honour to be, Sir,
Your obedient servant,
D. CARNEGIE.

WEIGHT OF MATERIALS USED IN SHELL CONTRACT.

Material	Rough Weight	Finished Weight
	Tons	Tons
Steel	141,953	70,977
Brass: 30% zinc.... 8,415 tons; 70% copper..19,635 tons; equals tons	28,050	4,208·7; 9,200·3; 14,029
Copper	3,630	1,815
Copper total, including copper in above brass	23,265	11,015·3
Lead, approximate	30,000	18,079
Tin, Sheet	300	211
Resin	....	1,431
Powder	....	1,407
Cordite	....	4,950
Trinitrotoluol	....	2,250

*These are not included in this report.

IV.

Colonel D. Carnegie, Chairman, Copper and Zinc Commission,
Ottawa, June 2nd, 1915.

General The Hon. Sam Hughes,
Minister of Militia and Defence,
Ottawa, Ontario.

Sir:—

I have the honour to enclose a few additional facts which confirm the conversation we had today on the subject of refining copper in Canada.

Since forwarding to you the preliminary report of the Commission, I have received letters from a number of users and manufacturers of refined imported copper in Canada, from whom the almost general opinion seems to be in favour of refining being carried out in the Dominion.

Such refining would lead undoubtedly to the manufacture of copper products in Canada, which are now imported; for instance, the attached will give an idea of the amount and value of the refined and manufactured copper and brass imported during the year 1913.

The industry of rolling brass and copper in Canada is simply in its infancy, and while it would be more expensive for some years to manufacture in Canada, than in the States, there cannot be two opinions regarding the advisability of taking some immediate action in this direction, if this industry is to be developed in Canada.

Apart from the foregoing, the strongest argument as far as I can see which could be advanced as a ground for immediate refining, is that of military necessity. The total copper required to meet the present demands for War Office contracts placed with the Shell Committee, amounts to over 23,000 tons. This amount, of course, is exclusive of the material referred to on the attached sheet, used in normal times.

Assuming that refining is commenced at the Trail Smelter on a daily production of fifteen tons of copper, working 365 days, only 5,475 tons would be produced, but this contribution would be of great assistance and would form the basis of an industry which could be developed both there and subsequently at the coast if found desirable.

As you have several times expressed a wish that some means might be found for utilizing the men now employed on munitions of war, after the war is over, this seems one way of making provision for such an employment.

I have the honour to be, Sir,

Your obedient servant,

D. CARNEGIE.

AMOUNT AND VALUE OF REFINED COPPER AND BRASS IMPORTED TO CANADA DURING 1913.

305,733 Cwt.	*Copper in bars and rods*	$5,103,844
44,811 Cwt.	*Copper in strips, sheets or plates*	874,070
889,056 Lbs.	*Copper tubing*	201,217
....	*Copper rollers*	8,647
51,216 Cwt.	*Copper in blocks, pigs or ingots*	847,394
5,691 Cwt.	*Copper, old or scrap*	82,274
2,254,884 Lbs.	*Brass tube (includes copper and zinc)*	471,193
54,499 Cwt.	*Brass bars or rods (includes copper and zinc)*	934,109
51,216 Cwt.	*Brass in blocks, pigs or ingots (includes copper and zinc)*	847,394
44,487 Cwt.	*Brass, old and scrap (includes copper and zinc)*	553,405
		$ 9,923,547

V.

James J. Warren, Esq.,

Penticton, B.C., 15th June, 1915

To General The Hon. Sam Hughes,
Minister of Militia,
Ottawa, Ontario.

Dear General Hughes:—

Re Zinc Supply.

You know that I am on the board of the Consolidated Mining and Smelting Company. I was at the smelter last Saturday, and learned that we were in a position to make zinc commercially, as a result of some successful experiments carried on at considerable expense during the past several years.

Ordinarily we would put in a small unit with the capacity of five tons per day, and work this for six or eight months before putting in a large plant. In this way we would no doubt discover some improvements which could and should be made before the large capital expenditure was decided on.

I feel that this programme would not be of the assistance to the Army that might be desired, and it occurred to me that possibly some arrangement might be made with you by which,

in view of the necessities of the situation, we should at once instal a plant, and produce as much zinc as possible, as soon as possible. This plant put in under such conditions, would in all probability be useless to us after its necessity, so far as you are concerned, was ended; hence my suggestion that the Government might aid the establishment by way of a loan, and not by way of subsidy. You will know that we are driving our plant to its utmost capacity to supply lead, and with this end in view we are spending some $350,000 on capital account. We have also made financial arrangements to take care of independent producers. These demands on us have long since taken up our capital, and we owe the Bank of Montreal a considerable sum of money. If the Government would lend the Consolidated Company enough to put in this plant, and would contract to take the supply of zinc that would be produced, I am prepared to recommend to the Board that such an arrangement be entered into at once, so that production of zinc for war purposes may begin at the earliest possible moment.

It is not a question of finding the ore from which to extract the zinc. We control a very large zinc property, and there are other producing mines in the neighbourhood. From these sources an adequate supply of raw ore could be readily obtained.

If on consideration you think that some arrangement can be made, I shall be glad if you will telegraph me, and I will proceed to Ottawa at once.

Yours very truly,

(Sgd.) JAMES J. WARREN.

VI.

James J. Warren, Esq.,

Penticton, B.C., 15th June, 1915.

David Carnegie, Esq.
Stephens Building,
Ottawa, Ontario.

Dear Mr. Carnegie:—

Re Zinc.

I telegraphed you from Trail on Saturday last. I suppose that you are pretty busy with other matters, and that it will

be a day or two before you can take this one up. I have written the Minister as per attached copy.

I am really anxious to do something to help the Army under its present necessities. You will be able to explain to the General the difficulties in connection with zinc refining, and the certainty that the plant we put up now will be scrapped the moment the present necessity for zinc no longer exists.

I was very pleased to find that we were producing zinc commercially, and though under present conditions it is costing us a good deal more than it should, we can produce zinc commercially and with prices considerably less than those now prevailing; we can do it, and can take care of the cost of the plant besides.

I am willing to go further than this, and recommend that we instal the Belgian process at some point where we can get natural gas, providing of course, that we can get the right kind of contract. We will not stand out for an extraordinary price, but will be prepared to meet you in the same spirit in which we have met you in regard to lead orders.

As a result of our policy of not standing out for the last cent, we are in trouble now with our shippers who want us to take their lead and settle for it on the present extreme prices. We have proposed to them that a pool be established covering all receipts at the Smelter from the 1st August until the end of the year, that the Consolidated and shipper each take the proper proportion of lead at the rate sold to the Shell Committee (5½c) and the proper proportion of lead sold for ordinary commercial purposes at the prices actually obtained therefor. Some are coming in, but some of our American friends are strenuously objecting.

I just mention this to let you know that the situation is not entirely happy.

With kind regards,

Yours very truly,

Encl./ (Sgd.) JAMES J. WARREN.

IX.

MEMORANDUM BY COL. D. CARNEGIE.

Presented to full Cabinet Council, Dominion Government, Ottawa, 24th June, 1915.

PROPOSALS TO PRODUCE METALLIC ZINC AND COPPER COMMERCIALLY IN CANADA.

1. As a military necessity.
2. To develop the zinc and copper industry throughout the Dominion.

SHELL COMMITTEE'S REQUIREMENTS.

Copper and Zinc for War Office Contracts.

For contracts already placed with the Committee, approximately 34,000 tons of brass are required, including 10,200 tons of zinc and 23,800 tons of copper. In addition to the foregoing 3,630 tons of copper are required for copper bands alone

Prices Copper and Zinc.

The Shell Committee have covered for nearly all the material required, but as the price of zinc has increased from 5c per lb. to 27c per lb. and that of copper from 12c per lb. to 21c per lb. within the last four months, the price of brass has risen from 16c per lb. to 36c per lb. making the price of cartridge cases almost prohibitive.

Means of Supply from Canada at Lower Prices.

In view of further orders being received from the War Office, it is imperative as a military necessity to take immediate steps to produce metallic zinc from the ores in the Dominion. By doing so it will insure a supply at reduced prices. The same remarks in some measure apply to copper if refining of that metal is done in Canada.

PROPOSALS RELATING TO ZINC REFINING.

Findings of Commissioners.

From very careful investigations made recently by the members of the Commission appointed by the Minister of Militia to enquire into the possibilities of refining zinc in Canada, it is shown that the time is opportune to commence refining by the electrolytic process. This process can be used for both high and low grade ores, whereas the ordinary processes of smelting with coal or gas are not applicable to at least 75% of B.C. ores.

Such refining would yield profitable results during the war and would also form the basis afterwards of a new industry for the supply of zinc for commercial purposes.

While operating the plant during the period of high prices, opportunities would be found for improving the process to make it a commercial success under normal conditions.

Companies ready to produce Zinc by Electrolytic Processes.

There are two companies ready to produce metallic zinc by what is known as the electrolytic method of refining. This is the only process by which the immediate treatment of low grade complex zinc ores in Canada can be attained with any measure of success.

Electro-Thermic Process a Failure.

The electrolytic process should not be confused with the experimental electro-thermic process which did not prove a success at the experimental plant in Nelson, B.C. In that plant an electric furnace was used for smelting and refining the ores.

Belgian Process not Feasible for Immediate use in Canada.

The Belgian process which is used in the United States, could not be operated successfully in Canada, for the following reasons:—

1. Scarcity of suitable ores (only about 25% of the ores mined in B.C. could be treated by this process.)
2. No assurance of continued supply of cheap gas and fuel.
3. Difficulty in obtaining skilled labour amd materials for maintaining the plant.

4. The time it would take to install such a plant in Canada, namely, 18 months to two years.

It could not therefore be recommended as an immediate means of production.

Proposals by the Consolidated Mining and Smelting Company.

At the Consolidated Mining and Smelting Company's plant at Trail, B.C. zinc is now being produced electrolytically by what is known as the "Letrange" process. They are making about 500 lbs. per day, and are prepared to extend their plant to meet the requirements of the Shell Committee, if a loan is given to them to cover the cost of additional plant. They have not only facilities for rapidly installing new plant, but have a capable staff for operating the plant when it is installed.

Cost of Producing Zinc in Canada Compared with Cost in U.S.A.

The cost of producing metallic zinc by the electrolytic process in Canada is approximately 5c per lb. whereas the cost in the United States by Belgian process, which perhaps is the most economical, does not exceed 2½c per lb. Even with a cost of 5c per lb. it is clear that while the market prices are so high, this industry could be maintained without any assistance from the Government, but if working under normal conditions, some assistance would be required.

Plentiful Supply of Zinc Ores.

There are now available zinc ores formerly sold to the United States, but which for the most part are at present without a market.

There is also available a large supply of ores of too low a grade to be marketed under normal conditions. These ores could be shipped easily to the works at Trail.

From the available ores at least 50 tons of metallic zinc could be produced daily by the electrolytic process.

Plenty of Electric Power.

There is a surplus of electric power at Bonnington Falls, B.C., available for the production of zinc by this process, and it is estimated that within four months the company could be in a position to work up to an output of 25 tons per day.

Proposal by Shell Committee.

The Shell Committee proposes that the Consolidated Mining and Smelting Company be asked to enlarge their plant to produce 25 tons of metallic zinc per day, the amount to be gradually increased to 50 tons.

The amount of money required for such extension to be advanced either by the Shell Committee or the Canadian Government, to be repaid in such amounts and at such periods as may be arranged between the Company and the Committee or Government.

Proposal from the Weedon Mining Company, Limited.

The Weedon Mining Company, Limited, of Weedon, Que., have developed an electrolytic process which they guarantee to produce about three tons of metallic zinc per day, commencing delivery in sixty days.

They propose to sell their entire output to the Shell Committee at a cost of 2c per lb. above the daily New York market prices. This figure can be reduced. They ask for some assurance that a continuance of the 2c extra per lb. be given to them for a period of two years to help them pay the cost of the necessary plant. The electrolytic process which they propose to operate has been under experimental operation for two years.

It is possible that this company might be satisfied with a loan on the same basis as that suggested for the Consolidated Mining and Smelting Company of Trail, B.C. That, of course, is subject to arrangement.

Necessity for Immediate Action.

It is, however, important, whatever method of assistance is given, that some steps be taken immediately to produce metallic zinc in the Dominion.

Proposals Regarding the Refining of Copper in Canada.

We attach copy of letter dated May 22nd, from the Consolidated Mining and Smelting Company of Canada, stating that they are prepared to start refining copper if assistance be given

in installing the necessary plant and a bounty in respect of each lb. of copper produced.

There is also attached copy of preliminary questions regarding the refining of copper in Canada by the Commission appointed by the Minister of Militia before investigating the subject. These questions are given in Section I. of this report.

X.

Dr. A. W. G. Wilson, Department of Mines,

Ottawa, 3rd July, 1915.

Col. D. Carnegie,
Chairman, Copper and Zinc Commission,
Ottawa.

Dear Mr. Carnegie:—

On Friday, during your absence from Ottawa, Hon. Mr. White convened the Committee of the Cabinet appointed to consider the report of the Copper and Zinc situation. On his instructions I was present at that meeting.

Hon. Mr. White has requested that the Shell Committee supply him with a statement setting forth their views on the following matters:—

1. Is there any substantial reason for assuming that the Shell Committee will be unable to secure all the copper it requires, either for existing or for future contracts, in the open market? If there are fears that the supply will be cut off or curtailed, on what data are these fears based?

2. Ditto with respect to zinc?

3. In what way do the Shell Committee consider that the Canadian zinc producers could be aided by the Government? (You will note that the Canadian Copper Mines are operating to capacity, while the zinc mines are closed because of lack of market for their ores.)

Mr. White instructed me to transmit these queries to you, and also advised me that the next meeting of the Committee would be called when the final reports were ready.

I would be much obliged if you would furnish me a copy of your memorandum that was presented to Council last week. You will remember that I did not have the opportunity of going over it with you and Dr. Stansfield in the Premier's office before the meeting.

Yours faithfully,
(Sgd.) ALFRED W. G. WILSON

XI.

The Honourable T. White, Minister of Finance,

Ottawa, July 7th, 1915.

Colonel D. Carnegie,
Chairman, Copper and Zinc Commission.
Ottawa, Ontario.

Dear Mr. Carnegie:—

Yesterday Senator Lougheed handed me your letter of the 5th instant stating that manufacturers now engaged in making brass cartridge cases for War Office contracts in Canada cannot obtain pure zinc for their work, and expressing the opinion that steps should be immediately taken to secure pure zinc from Canadian sources by the electrolytic process.

As the suggestion originally made to the Government, namely that capital should be advanced to the Consolidated Mining and Smelting Company at Trail for the purpose of establishing a refinery, involves an important question of policy I shall be glad if you and Dr. Wilson will carefully consider and advise me, for the information of the Committee, as to the following:—

1. Is it beyond doubt that the manufacturers in question will not be able to obtain zinc required for their work from United States or other sources? I have been informed in this connection that a ten months' supply of some nine thousand tons was contracted for about four months ago. Is this amount likely to be available and if so is it inadequate for the requirements of the next six months?

2. Is it established that the Consolidated Mining and Smelting Company can successfully treat our zinc ores by the electrolytic process? We should have some reliable statement as to this.

3. Would your object be attained by our agreeing to give a bounty upon a sliding scale, upon the same principle as we now grant lead bounties? The Weedon Mining Company have stated their willingness to erect a refinery at their own expense if a bounty of two cents per lb. is given upon zinc. It would appear to me that such a bounty, if given, should only apply when the price drops below a certain figure.

A meeting of the Committee was held this morning but unfortunately you were out of town. I should like to have the information in writing for a meeting to be held on Tuesday or Wednesday of next week, and shall be obliged if you will make arrangements to be in Ottawa upon that day.

I may say for your information that questions of policy are involved in the proposal to grant a subsidy or to make a loan to a particular company. Unless it is clear that zinc cannot be obtained except by some such assistance it would appear undesirable that, without fuller consideration on the part of the Government, we should commit ourselves to such special assistance.

Yours very truly,

(Sgd.) T. WHITE,

XII.

General A. Bertram,

Chairman, The Shell Committee,

Ottawa, 12th July, 1915.

The Honourable Thomas White,

Acting Premier for Dominion of Canada,

Ottawa, Ontario.

Dear Sir:—

I am forwarding you herewith correspondence relating to the manufacture of copper and zinc as set forth by our Ordnance Advisor, the Hon-Col. D. Carnegie, and on behalf of the Shell Committee I trust you will take this matter up and give it your serious consideration.

This is of vital importance to us for the reason that conditions are changing so rapidly with regard to the increase in price of this material and also its scarcity, that it may be impossible for us to obtain an adequate supply to meet the requirements of subsequent contracts from the War Office.

Hoping this matter will have your prompt and careful consideration, I remain.

Your obedient servant, ,

ALEX. BERTRAM.

Colonel D. Carnegie,
Chairman, Copper and Zinc Commission,
Ottawa, 12th July, 1915.

The Honourable Thomas White,
Acting Premier for Dominion of Canada,
Ottawa, Ontario.

Dear Mr. White:—

I received your letter of the 7th on my return to Ottawa on Saturday, with respect to securing a supply of zinc, and have had the opportunity of again discussing the matter with Dr. Wilson, and have pleasure in replying to your questions as follows:—

1. With reference to the possibility of obtaining sufficient zinc from the United States or elsewhere to meet the requirements of the Shell Committee in supplying ammunition to the War Office, I can definitely state that Horsehead and Bertha spelter cannot be obtained at the present moment for the manufacture of brass cartridge cases, and we see no possibility of obtaining an adequate supply for immediate requirements from existing sources. This is substantiated by enquiries I made in the United States while there last week.

2. Regarding the successful treatment of zinc by the electrolytic process established at the Consolidated Mining and Smelting Company's plant at Trail, B.C. this company is now producing 1000 lbs. of zinc per day, and we see no reason why a plant could not be installed to increase this output considerably.

3. We think it would be acceptable to establish a bounty upon a sliding scale on the same principle as you now grant to those producing lead, but this is a matter for negotiation with those concerned.

I enclose herewith copy of letter dated June 15th, from Mr. Warren a Director of the Consolidated Mining and Smelting Company of Trail, B.C.

With reference to the subject of copper it is probable that an adequate supply can be obtained from the United States

for existing and future contracts from the War Office. If, however, the United States should become involved in war and found it necessary to place an embargo on the export of copper, the situation would become serious. We therefore think some inducement should be given to encourage the refining of copper in Canada. The nature of this inducement is a matter for negotiation. We enclose herewith copy of letter on the subject from the Consolidated Mining and Smelting Company, dated May 22nd, and addressed to the Minister of Militia and Defence.

Yours very truly,

D. CARNEGIE.

PROPOSALS TO PRODUCE METALLIC ZINC COMMERCIALLY IN CANADA.

1st. As a Military Necessity, and
2nd. To Develop the Zinc Industry in the Dominion.

The Shell Committee's requirements in copper and zinc for the present British War Office contracts are as follows:—

Copper and Zinc ordered for present War Office contracts:—

Brass 28,050 tons, including 9,000 tons of zinc and 19,000 tons of copper.

In addition 3,630 tons of copper for copper bands.

These we have covered for, but as the price of zinc has increased from the normal value of 5c per lb. to 27c, and the copper from 12c to 21c, the cost of cartridge metal has risen within the last four months from 16c per lb. to 36c per lb., making the price of the cartridges almost prohibitive. To put in operation zinc refining in Canada at the present moment would bring the price of zinc down, and it would pay the Committee or the Government to give an inducement to companies prepared to refine in Canada from this consideration only.

Proposals re Zinc Refining.

From the investigations made by the Commission recently appointed by the Minister of Militia, the Commission have arrived at the following conclusions.

1. That as zinc is urgently required, the only available process for the immediate treatment of the low grade complex zinc ores in Canada is that of electrolytic refining. This process

should not be confused with the electro-thermic process, which did not prove a success at the experimental plant in Nelson, B.C.

Two companies in Canada have been experimenting with the electrolytic refining process, and are now prepared to extend their operations on a commercial basis and sell their entire output to the Shell Committee or the Government.

2. The experimental plant at Trail is producing approximately 1,000 lbs. of metallic zinc per day. This could be very greatly increased in the course of three months by suitable extensions of plant. It is estimated that the cost of producing metallic zinc by this process in Canada would be approximately 5c per lb. The cost of producing metallic zinc in the United States by the most economical process varies from 1½c to 2½c per lb.

The other company is the Weedon Mining Co., Ltd., of Weedon, Que., who have also developed an electrolytic process whereby they guarantee to produce 6,000 lbs of metallic zinc per day, commencing delivery in sixty days. They are prepared to sell their entire output to the Shell Committee at a cost of 2c per lb. above the daily current New York market price. They would require some assurance of the continuance of the 2c extra per lb. for two years, to help them pay the cost of necessary plant. The electrolytic process which they propose to operate has been in experimental operation for two years.

Proposals Regarding Copper.

These have already been placed before you in my letter dated 26th May, and in the letter of the Consolidated Mining and Smelting Company, of the 22nd May, and may be briefly summarized as follows:—

The said company is prepared to instal and produce ten to fifteen tons of refined copper per day, and to hold the entire production at the disposal of the Militia Department and Shell Committee, on the understanding that an advance of $50,000.00 be paid the company towards the cost of the plant, and a bounty in respect of each lb. of refined copper produced sufficient to put them on an equality as to the cost of refining only with American refining plants of large capacity.

From investigations made since writing to you on the 26th May, we have ascertained that the cost of refining blister

copper in the United States varies from .6c per lb. to 1c per lb., so that our estimate that the difference in the cost of refining in Canada and the United States should not exceed 2c per lb. is well within the limits of actual fact. The bounty, therefore, in any one year should not amount to $150,000 on the estimated daily output.

XIII.

Dr. Alfred Stansfield,
Montreal, June 28th, 1915.

Col. D. Carnegie, M.Inst., C.E.,
Shell Committee, Ottawa.

Dear Mr. Carnegie:—

I have a letter from T. French, relating to his father's process which is on trial at the Standard Mine, Silverton. He says the trial plant has been running for a month satisfactorily, (output not mentioned), and he thinks it will be adopted if the supply of ore warrants it.

Mr. Turnbull gave 4,000 tons as the probable output of that mine, which should mean 1,000 tons of zinc, or 3 tons daily.

This is the third independent source of zinc, all working on electrolytic methods. (That is Trail, Notre Dame de Anges, and Silverton.)

French speaks of the difficulty of raising capital for a large plant without government help, and also that the mine is far from power—50 miles from Bonnington Falls. I think that it might be worth while taking some special pains to see that the Standard Company are encouraged to try the French process, not merely in order to increase the zinc production, but to produce a healthy rivalry and increase the probability that the best process will finally be arrived at.

I am keeping the nickel situation in mind, and remain,

Yours very truly,

(Sgd.) ALFRED STANSFIELD.

XIV.

ZINC SPELTER.

Proposition received from the Consolidated Mining and Smelting Company of Canada, Limited.

Shell Committee to contract for 8,000 tons of zinc spelter at 15c per lb., f.o.b. Trail, B.C., delivery to be made at the rate of 25 tons per day beginning not later than five months from date of contract.

Further amounts of zinc spelter to be supplied at the same rate of delivery at 12½c per lb., f.o.b. Trail, B.C.

Quality.—Total impurities, other than copper, not to exceed one-tenth of one per cent.

BOUNTY.

After the expiration of the war, bounty to be granted on a sliding scale not to exceed 2c per lb. when the price of commercial zinc in London falls below £33 per ton of 2,000 lbs.; bounty provision to expire two years from the date of contract with Shell Committee. Total amount of bounty to be paid not to exceed $400,000. Bounty not payable on zinc spelter contracted for by Shell Committee at price of 8c or over per lb.

ORDERS PLACED.

An initial order for 8,000 tons of zinc at 15c per lb. was placed with the Canadian Consolidated Mining and Smelting Company. Orders have been placed also for refined copper.

1. Zinc Plant at Trail, B.C. Jan., 1916.

2. Construction. Oct. 18th, 1915—10 a.m.

3. General View of the Whole Construction. Oct. 25th, 1915—11 a.m.

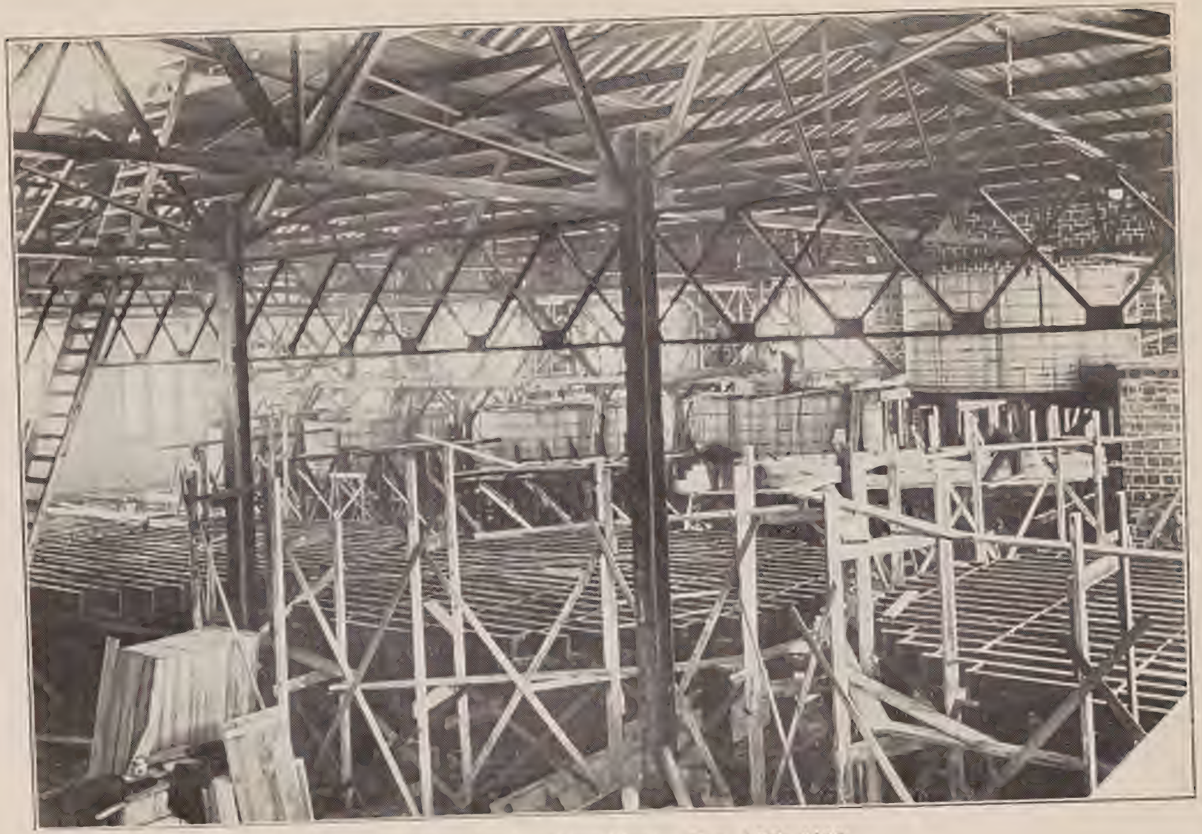
4. Generator Room, Electrolytic Plant and Sub-Station. Nov. 1st, 1915.

5. Leaching Plant and Upper End of Flue. Nov. 1st, 1915—1 p.m.

6. General View of Whole Construction. Nov. 30th, 1915.

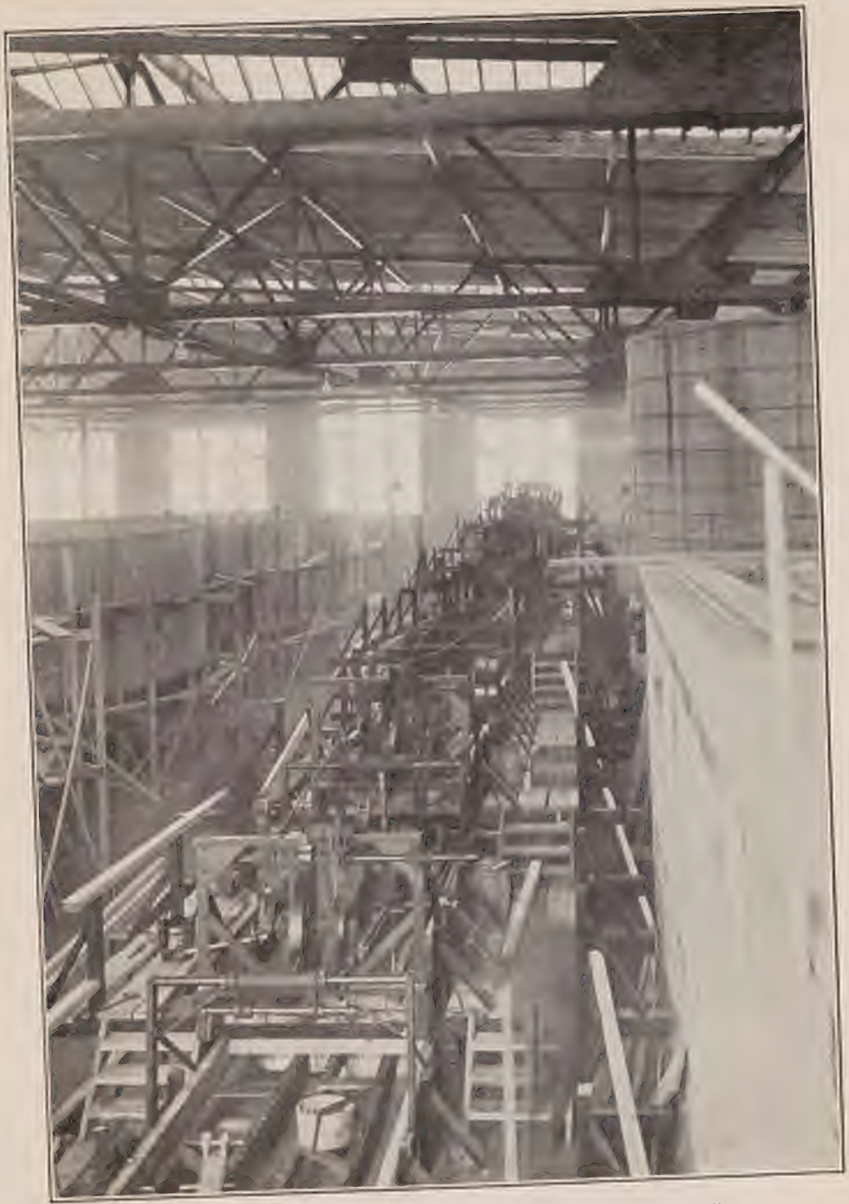
7. Generator Room, Electrolytic Plant, and Sub-Station. Dec. 6th, 1915.

8. Interior Electrolytic Tank Room. Dec. 13, 1915.



9. Interior Leaching Plant. Dec. 15th, 1915

10. Flue, Wedge Furnace Building and Cottrell Plant. Dec. 15, 1915.



11. Dorr Classifiers, Leaching Plant. Dec. 21st, 1915.

12. General View of Construction Dec. 28th, 1915.

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